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CHEMISTRY

and

TOXICOLOGY *for* NURSES

BY

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PHILADELPHIA AND LONDON

W. B. SAUNDERS COMPANY

1914

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PREFACE

In offering this volume to that class of noble and sacrificing women who are to devote their life's work to the aid of suffering humanity and to assist the physician in his labors, the author feels that a work of this small compass may be of service to them in the better understanding of the many problems with which they may be brought in daily contact. If, with all its simplicity, it be found of service to the great number following these fields of endeavor and they gain such information as will be of practical service to them, the author feels that his efforts will have been well repaid. It has been his constant aim to make this work as instructive as its compactness will permit, and his object has been to keep constantly before the student its practical import, so that this little volume may also be her companion after leaving her home of instruction.

The author was for a long time undecided to take up this task, but upon the earnest solicitation of his friends, thoroughly conversant with nursing, as to the need of a book of such elementary character, this work was undertaken. Yet, notwithstanding such encouragement, he feels that an apology is due for the very elementary nature of this work, and requests the reader to bear in mind that the treatise is not intended as a text-book of this most interesting science, with its many ramifica-

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tions, but merely as an aid to those taking up the study of Nursing, and if a more thorough knowledge of the subject is desired, it is advised that some of the numerous works upon chemistry be consulted.

Under the captions of those substances which are used in medicine there is given their medicinal properties, doses, and uses. No attempt has been made to give exact atomic and molecular weights, which have been rounded off to whole numbers. The text contains formulæ of compounds, which are added not with a view of abbreviation, but to familiarize the student with them.

Chemical equations are given with only the more important reactions, and, in a number of instances, with no intention of having the student study them, but merely as illustrations.

PHILIP ASHER.

NEW ORLEANS, LA.,
October, 1914.

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CHEMISTRY AND TOXICOLOGY FOR NURSES

INTRODUCTION

CHEMISTRY is the science that teaches of the elements and their compounds, and investigates the laws of their combinations.

Elements are those particles of matter that, up to the present time, have not been reduced to simpler ones. For example, oxygen is said to be an *element* because, no matter how it may be treated, it cannot be reduced any further. The same is true of iron and the other elements. *Water*, on the other hand, is a compound because we are able to decompose it into two elements, viz., *hydrogen* and *oxygen*.

ELEMENTS FOUND IN THE BODY

Carbon	13.5 per cent.
Hydrogen	9.1 "
Nitrogen	2.5 "
Oxygen	72.0 "

These constitute about 97 per cent. of the total body weight; the other 3 per cent. is divided in various proportions among the following elements: Phosphorus,

calcium, sulphur, sodium, potassium, chlorin, fluorin iron, silicon, magnesium, and arsenic.

The elements are divided into two classes: the metals and the non-metals; the former usually forming the bases of compounds, and the latter entering into the formation of acids.

The elements are expressed by **symbols.** Symbols are either single letters or two letters signifying the element they represent. For instance, *O* is the symbol of *oxygen;* it is the initial letter of that word. The commoner elements are usually expressed by a single letter, but when one element has the same initial letter as another element its difference is shown by adding a small letter to the initial letter of the element. For example, *carbon* is expressed by *C*, while *calcium* is *Ca*, and *cobalt* is *Co*.

The elements combine to form compounds which are divided into two main classes—the *organic* and *inorganic*.

NOMENCLATURE

Before the student can understand the study of chemistry, a knowledge of how the compounds are named is necessary.

The compounds are divided into a great number of classes, of which the *acids* and *salts* constitute a large majority.

Acids are defined as those substances which possess a sour taste and have the property of changing vegetable

colors, and which, when added to metals, give off hydrogen. They are divided into two main classes: the *binary acids* and the *oxyacids*.

A binary acid, as its name implies, is only composed of two elements. It contains no oxygen. An oxyacid is one containing oxygen.

A binary acid forms salts ending in "*id.*" In fact, all binary compounds, that is, those compounds composed of but two elements, end in "*id.*" HCl is the formula of hydrochloric acid, which, when it is added to a metal, forms a salt known as a *chlorid*. If iron were used, the salt formed would be iron chlor*id*. HBr is hydrobromic acid, and its compounds or salts are brom*ids*. If iron and sulphur were heated together, the resulting compound would be iron sulph*id*.

Oxyacids are subdivided into three classes: those containing the greatest amount of oxygen, called the "ic" acids; those with one atom of oxygen less than the "ic" acids, the "ous" acids; and those having still one atom of oxygen less than the "ous" acids, or two atoms of oxygen less than the "ic" acids, the "hypo—ous" acids. The oxyacids owe their characteristic property to an element which distinguishes them from the other oxyacids. For instance, the characteristic element of nitric acid is *nitrogen;* while in sulphuric acid it is *sulphur*. H_2SO_4 is the formula of *sulphuric* acid, it contains the largest amount of oxygen. H_2SO_3 is *sulphurous* acid, and it has one atom of oxygen less than

the preceding acid; H_2SO_2 is *hyposulphurous* acid and contains one atom of oxygen less than sulphur*ous* and two atoms less than the sulphur*ic*. The "ic" acids form salts ending in "*ate*"; the "ous" acids ending in "*ite*"; while the "hypo—ous" acids form the "hypo—ites." Thus, *e. g.*, sulphuric acid forms sulph*ates;* sulphurous acid forms sulph*ites;* while hyposulphurous acid produces hyposulph*ites*.

From a strictly theoretic point of view, all acids, whether binary or oxyacids, are divided in two parts: the *replaceable hydrogen* and the *acid radical*.

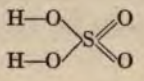
Replaceable hydrogen is THAT HYDROGEN that an acid contains which can be replaced by a metal or base. When an acid acts upon a metal an evolution of a gas is noticed; this gas is the *replaceable hydrogen* given off by the acid.

All acids contain hydrogen, but all the hydrogen of all acids cannot be replaced. *Sulphuric acid*, H_2SO_4, contains two atoms of hydrogen, both of which can be replaced. *Acetic acid*, $HC_2H_3O_2$, contains four atoms of hydrogen, only one of which can be replaced. For convenience the number of replaceable hydrogens an acid contains is shown by placing them at the beginning of the formula:

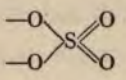
H_2SO_4	H_3PO_4	HNO_3	$HC_2H_3O_2$
Sulphuric acid.	Phosphoric acid.	Nitric acid.	Acetic acid.

Acid Radicle.—Radicles are groups of *unsaturated* elements playing the part of single elements. Radicles

cannot exist by themselves, only in combination, as nothing exists, from the chemical aspect, unless all its bonds or valencies are satisfied. The graphic formula of sulphuric acid, or the formula which portrays how each element in a compound is joined to the other, is



If the hydrogen is removed, there remains



in which two of its bonds are not taken up or are unsaturated, and which is usually expressed by $(SO_4)''$, the two dashes over it indicating its valence. As stated above, it can only exist in combination. It is the *acid radicle* of sulphuric acid, the part that remains after the removal of the *replaceable* hydrogen.

Valence is the relative volumetric proportion in which elements combine with one another. The combining power of H is taken as the standard or unit: it is said to have a combining power, valence, quantivalence, atomicity, or bond of one. In the formula H_2O it will be noticed that it takes 2 H to combine with one O; and since the valence of H is 1, as before said, and since it takes 2 H to combine with one O, the inference is that the valence of O is 2. The valence

or combining power of elements is usually expressed by dashes or Roman numerals placed over their symbols, thus:

$$\overset{\text{i}}{\text{H}} \text{ or } \overset{\prime}{\text{H}} \qquad \overset{\text{ii}}{\text{O}} \text{ or } \overset{\prime\prime}{\text{O}} \qquad \overset{\text{iii}}{\text{N}} \text{ or } \overset{\prime\prime\prime}{\text{N}} \qquad \overset{\text{v}}{\text{P}} \qquad \overset{\text{vi}}{\text{S}}$$

Valencies are also represented graphically, each dash indicating a valence or bond, as shown in the following examples:

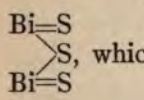
$$\text{—}\overset{\prime}{\text{N}}\text{—} \text{ or } \text{N}\equiv$$

If —O— were combined with one H, one of the bonds of O would remain unsaturated or unsatisfied, thus: H—O—. Under such a condition a compound cannot exist. If the remaining bond of O were taken up or combined with H, it would form H—O—H. Here all the bonds are saturated or satisfied, and the compound H_2O, or water, results.

Iron and sulphur each has two bonds, and, their valencies being equal, they combine in equal volumes: Fe=S or FeS.

But where the valencies of the elements are different, they combine in unequal volumes. If we take Bi (bismuth), which has three bonds, and S (sulphur), which has two bonds, it will be readily understood that were equal volumes of each element taken, one bond of the Bi would remain unsatisfied, thus: $\text{Bi}\overset{=}{\underset{-}{}}\text{S}$. As many volumes of S should be taken as there are bonds of Bi, namely, 3, and as many volumes of Bi

should be taken as there are bonds of S; namely, 2, so as to satisfy all the bonds, thus:



which, reduced to the ordinary formula, is Bi_2S_3.

Salts are acids in which all or part of the replaceable hydrogen has been replaced by a metal or base, and may also be regarded as a combination of either a metal or a base with an acid radicle. If all the H in H_2SO_4 were replaced by sodium (Na), it would form sodium sulphate, Na_2SO_4, while if only one of the hydrogen was replaced, sodium bisulphate, or acid sulphate, $NaHSO_4$, would be the result. The method of obtaining the correct formula of any salt will be shown by the following examples:

It is desired to know the formula of *potassium phosphite*. The symbol of potassium is K, and it has a *valence* of one, or, as it is frequently expressed, it has one *bond*. As was shown under the *oxyacids*, the "ous" acids form salts ending in "ite"; and as a phosph*ite* is desired, phosphor*ous* acid must be taken.

H_3PO_4 is phosphoric acid, and it was shown above that an "ous" acid contains one atom of oxygen less than the "ic" acid, so the formula of phosphor*ous* acid is H_3PO_3, removing the replaceable hydrogen (PO_3) remains, having a valence of three, as the valence of an acid is known by its number of replaceable hydrogen.

The next step is to combine the metal or base with the acid radicle. In this case it is the K with the $(\overset{'''}{PO_3})$, but it will be observed that each of these valencies differ, so that as many parts of the base or metal are taken as the valency of the acid radicle, which is three, and as many of the acid radicles are taken as there are bonds in the metal, which is one. Combining these in the proportions just outlined gives us a formula of $\overset{'}{K_3}(\overset{'''}{PO_3})$. In the example just shown it is not absolutely necessary to place the (PO_3) in parentheses, but examples will be shown in which it is most essential. It is desired to know the formula of *bismuth hyposulphite*. Bi is bismuth and it has three bonds. To produce a *hypo*sulph*ite* requires *hypo*sulphur*ous* acid, which has two atoms of oxygen less than H_2SO_4, making it H_2SO_2; its acid radicle will be $(\overset{''}{SO_2})$; combining these as indicated above gives us $\overset{'''}{Bi_2}(\overset{''}{SO_2})_3$. Two of the Bi were taken because the acid radicle has two bonds, and three of the acid radicles were used because Bi has three bonds.

Where the metal and acid radicle have the same valence, only one part of each need be taken. Copper sulphate is $\overset{''}{Cu}(\overset{''}{SO_4})$, as it will be seen that in this case both the copper and the acid radicle $(\overset{''}{SO_4})$ each have the same valence.

Bases.—The term "base" has several meanings. It is commonly defined in works on chemistry as a

substance which is soluble in water and will turn red litmus blue, and which, when combined with acids, forms salts.

In the definition of a "salt," given above, the term "base" has a somewhat different meaning, and applies to those groups of radicles with properties opposite to "acid radicles." Under the Chemistry of the Carbon Compounds (*q. v.*), "ethane" is shown to have the formula C_2H_6.

If one H is removed, the radicle, residue, or base "ethyl" (C_2H_5) remains. This combines with acid radicles, forming salts similarly to the above:

$(C_2H_5)Cl$,	$(C_2H_5)NO_3$,	$(C_2H_5)_2SO_4$
Ethyl chlorid.	Ethyl nitrate.	Ethyl sulphate.

(NH_4) is the radicle "ammonium," and is the base of the ammonium compounds, and, when combined with acid radicles, it forms salts:

$(NH_4)Cl$,	$(NH_4)NO_3$,	$(NH_4)2SO_4$
Ammonium chlorid.	Ammonium nitrate.	Ammonium sulphate.

Atomic Weight.—In the formula of H_2SO_4 the elements composing it are to be regarded as if they exist by volume, and that there are two volumes of H, one of S, and four of O, provided each element was in the gaseous state.

In considering the weight of each element in H_2SO_4 we find a great difference. If equal volumes of H and

O were taken, the weight of each volume would be different. Since hydrogen is the lightest substance known, it is taken as the standard, and it would be found that an equal volume of oxygen would weigh sixteen times more than hydrogen. It will also be found that when elements combine with one another they do so in proportion to their atomic weight, based upon the valence of one. Atomic weight may then be defined as the weight of an element compared to the weight of an equal volume of hydrogen or the relative weight which elements combine with one another, based upon the valence of one.

Molecular Weight.—When two or more atoms combine they form molecules, and the combined weight of these atoms is known as *molecular weight.* In H_2SO_4 we have two volumes of H with an atomic weight of one for each of the H, or two for both; sulphur has an atomic weight of thirty-two; and the four O, each with an atomic weight of sixteen, or sixty-four; the sum of these will be ninety-eight, or we state that the *molecular weight* of H_2SO_4 is ninety-eight.

Chemistry deals only with material things, such as we may appreciate by the various senses. Hence, *matter* is defined as anything occupying space. It may be either visible or invisible. Iron is *matter* which can be seen; but we are constantly surrounded by *matter* which cannot be seen, the air; yet it is *matter* because it occupies space.

Matter is divided according to its size into *masses*, *molecules*, and *atoms*.

A **mass** is a large aggregation of molecules.

A **molecule** is the smallest particle of *matter* that can exist by itself, and it is composed of at least two atoms.

An **atom** is the smallest particle of *matter* that can exist even in combination, and as two or more atoms produce a molecule, atoms do not exist in the free state.

PART I

NON-METALLIC ELEMENTS

HYDROGEN

Symbol, H; Atomic weight, 1; Molecular weight, 2; Density, 2; Valence, 1.

Discovered by Paracelsus in the 16th century; its elementary nature was first recognized by Cavendish. Its name is derived from the Greek, *hudor*, water, and *gennao*, to generate, in allusion to the formation of water when burned in the presence of air or oxygen.

Occurrence in Nature.—Hydrogen is found in water, of which it constitutes two-thirds by volume, when water is decomposed into its components, and one-ninth by weight. It is found in all acids. No true acid exists unless it contains hydrogen. It is contained in all animal and vegetable matter.

Preparation.—Hydrogen can be obtained from water, which has previously been acidified with H_2SO_4, by passing a current of electricity through it.

$$H_2O = 2H + O$$

It is made whenever a dilute acid acts upon a metal.

$$\underset{\text{Zinc.}}{Zn} + H_2SO_4 = \underset{\text{Zinc sulphate.}}{ZnSO_4} + 2H$$

$$\underset{\text{Iron.}}{Fe} + 2HCl = \underset{\text{Iron chloride.}}{FeCl_2} + 2H$$

(Hydrochloric acid.)

Properties.—It is a colorless, odorless, and tasteless gas. It is a non-supporter of life and combustion, and when ignited combines with oxygen to form water. Under cold and pressure it can be liquefied and also converted into the solid state. It is the lightest substance known, and on this account is taken as the unit of atomic weight and density of gases. Its density compared to air is .0692. One liter at 0° C. (32° F.) and barometric pressure of 760 mm. weighs .0896 gm.; 100 cubic inches weigh 2.26 gr. When mixed with air or oxygen and ignited it combines with explosive force, so that care must be exercised in seeing that all the oxygen is out of the generator before igniting it.

OXYGEN

Symbol, O; Atomic weight, 16; Molecular weight, 32; Density, 16; Valence, 2.

Discovered by Priestly in 1774 and about the same time by Scheele, but independently of the former discoverer. It was called oxygen, from *oxus*, an acid, and *gennao*, to generate, from the belief that it was essential to all acids, but, as has been shown under Binary Acids, these contain no oxygen.

Occurrence in Nature.—Oxygen is found in the atmosphere, of which it constitutes about one-fifth by volume. It forms between 33 and 45 per cent. of the earth's crust. It is contained in water, forming one-third by volume and eight-ninths of it by weight. It

is also found throughout the animal and vegetable kingdoms.

Preparation.—At one time it was largely made by heating potassium chlorate; and when made by this method and was to be used for medicinal purposes it was freed from the accompanying chlorin by passing it through flasks containing a solution of sodium hydroxid and then through water.

$$\underset{\text{Potassium chlorate.}}{KClO_3} = 3O + \underset{\text{Potassium chloride.}}{KCl}$$

Since electricity is cheaply obtained today, it is used to decompose water, as shown under Hydrogen.

Properties.—It is a colorless, odorless, and tasteless gas, which under cold and pressure may be both liquefied and solidified. It combines with all elements except fluorin, which up to the present time has not been combined with it, either directly or indirectly. Water dissolves about 3 per cent. of it by volume and its solution in water is of great importance. Water that has stood in a warm place loses its dissolved oxygen and possesses a flat taste, and can be revivified by passing it from one vessel to another. Its presence enables fish to live in water, as these animals breathe it through their gills. It also serves as a purifying agent by burning up the organic impurities that may be contained in water. This is why a running stream that has had sewerage emptied into it may, within a few miles from the source of contamination, be found to be practically

free of same. It is a supportor of life and combustion, as nothing can live nor burn without it. Hence, to cut off its supply would extinguish both life and flame.

Uses.—It is largely used today in those diseases where an insufficiency of it is supplied to the system. It is also used to resuscitate persons after drowning, and is more beneficial in such cases than artificial respiration.

OZONE

Symbol, $O^{'''}$; Valence, 3; Molecular weight, 48.

This is an allotropic form of oxygen, and is produced when non-luminous electric discharges are passed through oxygen. It may also be called condensed oxygen. In its production three molecules of oxygen are condensed to form two molecules of ozone, according to the following equation:

$$3O_2'' = 2O_3'''$$

It differs from oxygen by possessing a disagreeable odor, from which its name was derived (*ozus*, meaning stench), and by being more active in its chemical behavior than oxygen. Substances that are not affected by oxygen are readily decomposed by it. At one time the popular belief was that it was contained in country air, but this was shown to be erroneous. It was also supposed to possess disinfectant properties, but this has not been verified by experiment, and recent researches have shown that the quantity sufficient to do so has

an irritating and harmful effect upon persons inhaling it. A simple test for its presence is to expose starched paper, moistened with potassium iodid; the ozone liberates the iodin from the potassium iodid, and the iodin, in turn, acts upon the starch, turning it blue. This test, however, is not only true of ozone, but is also produced by other substances. When lightning passes through the atmosphere it produces ozone. It is also made by exposing moist phosphorus to the air.

Allotropism.—We have seen that oxygen and ozone are composed of the same substance, yet possess different properties. When such a condition is met in chemistry the name *allotropism* is applied to it, which is defined as that property that elements possess of existing in two or more forms and exhibiting different physical properties. The molecule of oxygen has two atoms while ozone has three.

WATER

Formula, H_2O; Molecular weight, 18; Density in gaseous condition, 9.

Sources.—Water is widely distributed throughout the animal and vegetable kingdoms. The human body is composed of about seven-tenths of it. In potatoes we find about 75 per cent., and in watermelons as much as 94 per cent.

It is found in the air as fog, rain, dew, and snow. In the liquid form it is found in wells, springs, rivers, lakes, seas, and oceans.

Forms.—It exists in the three states of matter: gas, liquid, and solid.

In its solid form it is known as ice; in the gaseous state it exists as vapor or steam. It is composed of two volumes of hydrogen and one volume of oxygen. It boils at 100° C. (212° F.), freezes at 0° C. (32° F.), and reaches its point of maximum density at 4° C. (39° F.). At the latter temperature a given volume of water will weigh more than it does at any other temperature.

When water is cooled below 39° F. it expands in volume until 32° F. is reached. In this respect it forms an exception to the rule that heat expands and cold contracts. It is a poor conductor of heat and electricity.

Water is divided into two classes: *hard* and *soft*. A water that does not readily lather with soap is termed *hard;* while one that will, is called *soft*. The hard waters are further subdivided into two other classes: the *temporary* and *permanent* (hard). The former, as its name implies, can have its hardness removed, either by boiling or chemical means, while the latter cannot.

The hardness of the temporary hard water is principally due to calcium bicarbonate, while the permanent owes its property largely to calcium sulphate, but other substances may also play some part.

Its function in the body, according to Dr. Gilman Thompson, can be summarized as follows:

(1) It enters into the chemical combination of the tissues.

(2) It forms the chief ingredient of all fluids of the body and maintains their degree of dilution.

(3) By moistening various surfaces of the body, such as the mucous and serous membranes, it prevents friction and the uncomfortable symptoms that might result from their drying.

(4) It furnishes in the blood and lymph a fluid medium by which the food may be taken to remote parts of the body and the waste material removed, thus producing rapid tissue changes.

(5) It serves as a distributor of body heat.

(6) It regulates the body temperature by the physical processes of absorption and evaporation.

The amount eliminated daily from the body is about 3 liters, distributed as follows: Exhalation from the lungs, 20 per cent.; cutaneous perspiration, 30 per cent.; and by the urine and feces, 50 per cent.

Water has been found to be the source by which disease has been conveyed, and should never be used when there is the faintest suspicion of its purity, unless it has been thoroughly boiled. This absolutely kills all germs that may be contained in it. It should be stored for use in bottles which have been thoroughly cleaned by boiling, and which unless so treated would only contaminate the water placed in them.

Drinking-water.—A good drinking-water is one that is free from color, odor and taste, and practically free from organic matter. This latter substance, if it is contained in a running stream, is burnt up by the oxygen contained in it.

Mineral Waters.—This class of waters has been very much abused, and their real virtues, in the majority of cases, do not depend upon their constituents so much as upon the psychologic effect and the large amounts consumed.

They are defined as waters containing some abnormal constituent or those that contain an excess of a normal constituent. If a water contains arsenic, bromin, sulphur, or any ingredient that is not found in ordinary water, it can be placed in the former class; but if it should contain an excess of sodium chlorid, carbon dioxid, substances usually found in the average water, it belongs to the latter class. They are classified according to their predominating constituents: such as bitter waters, containing large quantities of magnesium salts; iron or chalybeate waters, containing sulphate or bicarbonate of iron; sulphur waters, containing sodium or hydrogen sulphid; effervescent waters, containing carbon dioxid.

Distilled Water.—This is a water obtained by boiling water, rejecting the first portion of the distillate (containing the volatile or gaseous impurities, such as chlorin, ammonia, and hydrogen sulphid), and preserving the

balance. The distillation is not carried to completion, as the solid impurities must be left behind.

Water of crystallization is that water that some substances contain and to which they owe their crystalline form. Copperas is $FeSO_4.10H_2O$, and its crystalline form is due to the 10 molecules of water of crystallization it contains. If it were exposed to air or heated, it would lose its crystalline form and fall to a powder. This does not imply that all chemicals of a crystalline nature owe such form to water of crystallization; there are numerous substances that possess a crystalline form without containing any water of crystallization; for instance, boric, salicylic, and tartaric acids, potassium bromid and iodid, and a host of others. Substances that absorb moisture from the air and become liquid are termed *deliquescent*. Those that give up their water of crystallization upon exposure to the air or by heat, and become pulverous, are termed *efflorescent*, *exsiccated*, *dried*, or *anhydrous*.

HYDROGEN PEROXID OR HYDROGEN DIOXID

Formula, H_2O_2; Molecular weight, 44.

This substance is made by the action of acids upon certain metallic dioxids. For commercial purposes barium dioxid and sulphuric acid are used, and the H_2O_2 is filtered off of the insoluble barium sulphate.

$$\underset{\text{Barium dioxid.}}{BaO_2} + H_2SO_4 = H_2O_2 + \underset{\text{Barium sulphate.}}{BaSO_4}$$

The pure substance is an oily liquid, colorless, soluble in water, alcohol, and ether. A solution containing 50 per cent. is used by dentists for bleaching the teeth. The official solution of H_2O_2 is *Aqua hydrogenii dioxidi*, contains 3 per cent. by weight of H_2O_2, and yields 10 volumes of oxygen. As it readily undergoes decomposition, it is preserved by the addition of small amounts of acetanilid.

It possesses bleaching and antiseptic properties. It produces an effervescence with pus and other organic matter due to its liberation of oxygen.

A delicate test for its presence is to place in a test-tube a few drops of a solution of potassium dichromate, $K_2Cr_2O_7$, followed by a few drops of H_2SO_4 and a layer of ether, then add the liquid suspected of containing the H_2O_2 or a dioxid and shake. The ethereal layer will turn blue.

NITROGEN

Symbol, N; Atomic weight, 14; Molecular weight, 28; Density, 14; Valence, 1, 3, 5.

Occurrence in Nature.—This substance is found uncombined in the atmosphere, of which it constitutes four-fifths by volume. It also occurs in the animal and some of the vegetable kingdom and in mineral deposits, as either potassium or sodium nitrates.

Preparation.—It can be prepared by burning phosphorus under a bell-jar. This removes the oxygen from the air, leaving N. It is also prepared chemically

by heating a solution of ammonium chlorid with sodium nitrite.

$$\underset{\text{Ammonium chlorid.}}{NH_4Cl} + \underset{\text{Sodium nitrite.}}{NaNO_2} = 2N + \underset{\text{Sodium chlorid.}}{NaCl} + 2H_2O$$

Properties.—It is a colorless, odorless, and tasteless gas, which under cold and pressure can be both liquefied and solidified. It is a non-supporter of life and combustion. It forms an essential constituent of a large number of animal and some vegetable substances, and is necessary for both animal and plant life. Its use in the air is to dilute the oxygen. In body building and repair the nitrogen of protein food plays a very important part. In the other bodily functions nitrogen is not utilized.

AMMONIA

Formula, NH_3; Molecular weight, 17; Density, 8.5.

This compound is constantly being formed in nature through the decomposition of organic matter—chiefly animal, such as flesh, blood, urine, etc. It is also produced during the process of *destructive distillation*, which is heating organic matter in large retorts to a high heat, ...thout the access of air, whereby the original sub...ce is destroyed and new compounds produced, which ...llected in proper receivers. In the manufacture ...ating gas, coal is subjected to this process, ... contained in the coal is converted into ...rgely the source of the ammonium ...rce.

Ammonia is *always* obtained when any ammonium compound is heated with the caustic alkalis or alkaline earths.

$$\underset{\text{Ammonium chlorid.}}{NH_4Cl} + \underset{\text{Potassium hydroxid.}}{KOH} = NH_3 + \underset{\text{Potassium chlorid.}}{KCl} + H_2O$$

$$\underset{\text{Ammonium sulphate.}}{(NH_4)_2SO_4} + \underset{\text{Calcium hydroxid.}}{Ca(OH)_2} = 2NH_3 + \underset{\text{Calcium sulphate.}}{CaSO_4} + 2H_2O$$

Properties.—It is a colorless gas with a very pungent odor, an alkaline taste, and strong alkaline reaction. Like other gases, it can be liquefied and solidified. It is exceedingly soluble in water, which at ordinary temperature dissolves over seven hundred times its own volume of the gas. Its solution in water produces *ammonia-water*, of which two strengths are official in the U. S. P.: *Aqua ammonia*, containing 10 per cent. by weight of the gas, and *Aqua ammonia fortior*, containing 28 per cent. Ammonia combines directly with acids, forming the ammonium compounds, in which nitrogen is pentavalent, or has a valence of five.

Toxicology.—Ammonia-water is a caustic. When it is taken internally, organic acids in the form of vinegar or lemon-juice should be administered, followed by demulcent drinks and bland oils. No emetic need be given, as the neutralized ammonium compounds produced are harmless. If the caustic effect is extensive there is danger of rupture, produced by vomiting.

COMPOUNDS OF NITROGEN AND OXYGEN

Five distinct compounds of nitrogen and oxygen are known. Some of these are unimportant to those following the medical sciences, but are of great industrial importance in the chemical world.

	Composition			
	By weight.		By volume.	
	N	O	N	O
Nitrogen monoxid.....N_2O	28	16	2	1
Nitric oxid or dioxid.....N_2O_2 or NO	28	32	2	2
Nitrogen trioxid.....N_2O_3	28	48	2	3
Nitrogen tetroxid.....N_2O_4 or NO_2	28	64	2	4
Nitrogen pentoxid.....N_2O_5	28	80	2	5

NITROGEN MONOXID (also known as Laughing-gas and Nitrous Oxid)

Formula, N_2O; Molecular weight, 44; Density, 22.

Preparation.—Nitrogen monoxid is made by heating ammonium nitrate.

$$NH_4NO_3 = N_2O + 2H_2O$$

This gas is largely used as an anesthetic in dentistry and as an adjunct in general surgical anesthesia. When made for such purposes, the gas is purified by passing through wash-bottles containing caustic soda, ferrous sulphate, and water respectively.

Properties.—It is a colorless, almost odorless gas, possessing a sweet taste. It is a supporter of combustion almost as energetic as oxygen. When inhaled it causes exhilaration, intoxication, anesthesia, and, finally, asphyxia.

NITROGEN DIOXID OR NITRIC OXID

Formula, NO or N_2O_2; Molecular weight, 30; Density, 15.

Properties.—A colorless gas which, upon exposure to air or oxygen, forms a poisonous suffocating gas of deep-red color, due to its change to *nitrogen tetroxid* or *peroxid*, N_2O_4. It is prepared by the action of nitric acid upon metals or such substances that reduce the HNO_3.

$$3Cu + \underset{\text{Nitric acid.}}{8HNO_3} = \underset{\text{Copper nitrate.}}{3Cu(NO_3)_2} + 2NO + 4H_2O$$

Nitrogen Trioxid (N_2O_3).—It is yet doubtful whether this gas exists. When arsenous oxid is treated with nitric acid, a gas of the above composition is produced, but it is regarded as a mixture of equal volumes of N_2O_2 and N_2O_4.

Nitrogen pentoxid (N_2O_5) is a solid which, upon the addition of water, forms nitric acid and is of scientific interest only.

NITRIC ACID (Acidum Nitricum)

Formula, HNO_3; Molecular weight, 63.

This acid is found, in nature, combined with potassium, known as *niter* or saltpeter; also with sodium, as Chili saltpeter. These compounds are produced by the action of certain bacteria, converting the ammonia, produced by the decomposition of nitrogenous organic matter, into nitrous and, ultimately, into nitric acid.

Preparation.—Usually prepared commercially by the action of sulphuric acid upon potassium or sodium nitrate.

$$\underset{\text{Potassium nitrate.}}{2KNO_3} + H_2SO_4 = K_2SO_4 + \underset{\text{Potassium sulphate.}}{2HNO_3}$$

Properties.—It is a colorless, corrosive liquid; when exposed to the air it gives off vapors of a peculiar suffocating odor, and it is a powerful oxidizing agent. The official acid contains 68 per cent. by weight of HNO_3 and 32 per cent. water. The *dilute nitric acid* contains 10 per cent. of absolute HNO_3. The acid is wholly volatilized by heat, stains animal matter yellow, and destroys tissue. Iodin forms a stain somewhat similar in color, which can be told from stains produced by HNO_3 by becoming lighter in color or entirely disappearing when treated with ammonia-water, while HNO_3 under like conditions turns an orange color. The acid is monobasic; that is, has but one *replaceable hydrogen*, forming with metals or bases the nitrates. All nitrates are soluble in water and, consequently, the test for it or its salts cannot be made by precipitation, as is commonly done with other acids. The dilute acid is made by taking 10 parts by weight of the strong acid and adding to it 58 parts of water. All the official dilute acids contain 10 per cent. of absolute acid, except dilute acetic, which contains 6 per cent., and dilute hydrocyanic acid, which contains 2 per cent.

Tests.—In a test-tube is placed some strong H_2SO_4

and to this (the tube being held in a slanting position, so as not to mix the solutions) a solution of ferrous sulphate, $FeSO_4$, is added; then a few drops of the substance to be tested. The tube is gently tapped, so as to bring the suspected liquid in contact with the H_2SO_4, and a reddish-brown zone at the point of contact of the two liquids indicates HNO_3, or a nitrate.

THE AIR OR ATMOSPHERE

This is essentially a mixture of about 77 volumes of nitrogen, 21 of oxygen, and contains, in addition to these, from .03 to .04 part of carbon dioxid, from 0.5 to 1.4 parts of aqueous vapor, with traces of NH_3, HNO_3, and HNO_2.

That the air is a mixture and not a compound can readily be shown by simple experiments. If some phosphorus is burned under a bell-jar placed over water, it will burn as long as oxygen is present. As the oxygen is being removed the water will rise in the bell-jar and will show approximately the volume of oxygen that has been removed. If air is shaken with lime-water, $Ca(OH)_2$, the latter becomes cloudy, due to the CO_2 of the atmosphere forming calcium carbonate, $CaCO_3$, with it.

It is claimed that the air envelops the earth, ranging from 50 to 200 miles in height. It exerts a pressure upon every part of the earth's surface of about 15 (accurately 14.7) lbs. to the square inch. This pres-

sure is sufficient to maintain a column of mercury 30 inches high or water 32.4 feet.

CARBON

Symbol, C.; Atomic weight, 12.

Occurrence in Nature.—This element is a constituent of all organic matter. In the pure state it exists in three allotropic modifications, viz., in the crystalline state, as diamond and graphite, and in the amorphous state in various forms, as charcoal, bone-black, lamp-black, etc. It is found as calcium carbonate in limestone, oyster shell, marble, and coral; as carbon dioxid in the atmosphere and water. The *diamond* is the purest form of carbon. It is crystalline, insoluble in all substances, and infusible, but if sufficiently heated in a current of pure oxygen it will burn. It is the hardest natural substance known and is used for drilling and cutting glass.

Graphite, *black lead*, *plumbago*, is a black, metallic-looking substance, very soft, with an unctuous or slippery feel, and leaves a black mark when drawn across paper. It is employed in the manufacture of lead pencils, as a lubricant, and as a protective agent, preventing oxidation of surfaces with which it is coated.

Amorphous carbon exists in various forms, as lamp-black, charcoal, and bone-black. Charcoal and bone-black are obtained as residues in the destructive distillation of wood and bones. They are of an intensely

black color, porous, and have the property of absorbing large amounts of gases. They are also deodorizing, decolorizing, and reducing agents. In the industries they are used to remove organic coloring-matter. In the manufacture of white sugar, the colored solution is passed through long filters containing bone-black.

The official charcoals are *Carbo ligni*, *Carbo animalis*, and *Carbo animalis purificatus*.

Carbon and Oxygen.—There are two compounds of carbon and oxygen: carbon monoxid and carbon dioxid.

CARBON DIOXID

Formula, CO_2; Molecular weight, 44; Density, 22.

Also called carbonic acid gas and carbonic anhydrid.[1]

Preparation.—It is formed when carbon is burned with a full supply of oxygen.

$$C + 2O = CO_2$$

It is also made by the process of *calcination*, which is heating a carbonate to deprive it of CO_2. CO_2 is always evolved and an oxid left.

$$\underset{\text{Magnesium carbonate.}}{MgCO_3} = CO_2 + \underset{\text{Magnesium oxid.}}{MgO}$$

[1] An acid anhydrid is defined as an acid from which all the H and O, in the proportion to form H_2O, has been removed. Acid anhydrids contain no hydrogen. If from H_2SO_4, H_2O is removed, SO_3 remains, and is called *sulphuric anhydrid*. H_2CO_3 is carbonic acid; removing H_2O leaves CO_2, or *carbonic anhydrid*.

Another method of making it is by treating any carbonate with any acid.

$$\underset{\text{Calcium carbonate.}}{CaCO_3} + 2HCl = CO_2 + \underset{\text{Calcium chlorid.}}{CaCl_2} + H_2O$$

Carbon dioxid is formed through decay of organic matter. It is produced by the respiration; the inhaled air absorbed in the lungs by the blood combines with the carbon of the system, forming CO_2. Its presence can be shown by blowing into lime-water. It produces with the latter a cloudiness, due to the formation of calcium carbonate. The exhaled air contains 4 per cent. by volume of CO_2, which is one hundred times more than is contained in fresh air. CO_2 is contained in air to the extent of about 4 volumes in 10,000. It is contained in spring-waters, but some of it escapes as it rises to the surface. CO_2 is always formed during the process of fermentation.

Properties.—It is a colorless gas, having a slight acid taste with little odor. Under cold and pressure it can be liquefied and solidified. The liquid CO_2 is largely used to make the so-called "soda water" and also for freezing specimens in making anatomic and pathologic sections. The solid CO_2 is known as "CO_2 snow" and is used as a cauterizing agent. The gas is about one and a half times heavier than air. It is a non-supportor of life and combustion, 10 per cent. being sufficient to extinguish flame. One volume of cold water dissolves

its own volume of CO_2. Under pressure the solubility is increased. Each increase of one atmosphere dissolves one volume more of CO_2. It is non-poisonous by the stomach, acting as a sedative to the mucous membrane. When inhaled it produces spasm of the glottis, and causes death by cutting off the supply of O and preventing proper exchange between the CO_2 of the blood and the O of the air. It is also used to extinguish flame; being heavier than air, it acts as a blanket.

According to Andral and Gavarret, the average amount of CO_2 exhaled per hour by an adult is nearly 0.8 cubic foot. The air space for healthy individuals should not be less than 400 cubic feet, but for the sick this should be increased two or three times. Unless some provision was made by nature to remove the CO_2 that is constantly being produced, the amount contained in the air would be greatly increased. Plants absorb it as food, retaining the C and liberating the O, thus keeping the constituents of the air in equilibrium.

Carbonic Acid (H_2CO_3).—When CO_2 is passed into water it combines with it, forming H_2CO_3.

$$CO_2 + H_2O = H_2CO_3$$

This has been proved to be an acid, possessing both chemical and theoretic properties of a true acid. It is, however, a very weak acid, and forms two classes of salts, the normal and acid carbonates.

Carbonates.—These may be considered as *carbonic acid* in which one or both of its hydrogens have been replaced by metals or bases.

$HHCO_3$ (another way of showing the formula of acids), replacing one of the hydrogens by Na, would produce $NaHCO_3$; bicarbonate or acid carbonate of sodium replacing both the hydrogens, forming Na, $NaCO_3$ (sodium carbonate), or Na_2CO_3.

Test for Carbonates.—Any carbonate or bicarbonate treated with an acid produces an effervescence of CO_2, which, when passed into lime-water, produces a turbidity of $CaCO_3$.

Solution of barium chlorid added to a solution of a carbonate produces a white precipitate of barium carbonate, $BaCO_3$, wholly soluble, with effervescence, in HCl.

Carbon Monoxid, *Carbonic Oxid* (Formula, CO; Molecular Weight, 28; Density, 14).—Carbon, as a general rule, has a valence of 4, but in carbon monoxid the valence is 2.

Properties.—It is a colorless, odorless, tasteless gas, a non-supporter of life and combustion, and burns with a blue flame, forming CO_2. Almost insoluble in water. Poisonous when inhaled, forming with the blood *carbon monoxid hemoglobin.* Blood containing carbon monoxid hemoglobin is bright red and, when examined with the spectroscope, presents bands characteristic to oxyhemoglobin, but which can be distinguished from the latter by not being changed by reducing agents.

Toxicology.—In poisoning by CO, remove any gas present in the lungs by inhalations of O or by artificial respiration. If this fails, transfusion of blood may be resorted to. Stimulants and iron may also be given.

Preparation.—CO is formed when CO_2 is passed over heated carbon. The blue flame playing around a coal fire is the CO burning.

$$CO_2 + C = 2CO$$

It is also prepared by the action of strong H_2SO_4 upon *oxalic acid.*

$$\underset{\text{Oxalic acid.}}{H_2C_2O_4} + (H_2SO_4) = CO + CO_2 + H_2O$$

The sulphuric acid, in the above reaction, being a powerful dehydrating agent, removes the elements of water, H and O, from the oxalic acid.

The compounds of C and H are quite numerous; they will be considered under Organic Chemistry.

Cyanogen (Formula, $(CN)_2$; Molecular Weight, 52; Density, 26).—This is a colorless, poisonous gas, burning with a peach-colored flame, producing CO_2 and liberating N.

Preparation.—It is made by heating mercury cyanid.

$$\underset{\text{Mercury cyanid.}}{2Hg(CN)_2} = 2Hg + 2(CN)_2$$

Hydrocyanic Acid, *Prussic Acid* (Formula, HCN; Molecular Weight 27).—This acid does not exist in nature in the free condition, but is produced from such

substances as wild cherry bark, bitter almonds, and peach kernels, when acted upon by water. In reality, this is due to the glucosid, *amygdalin*, contained in them, being acted upon by the ferment, *emulsin*. The pure acid is never found in commerce. It is a colorless liquid of a characteristic penetrating odor, resembling bitter almonds, readily soluble in water.

It is made commercially by the interaction between H_2SO_4 and potassium ferrocyanid. The dilute acid, as found in pharmacy, *Acidum hydrocyanicum dilutum*, contains 2 per cent. by weight of absolute HCN; it readily deteriorates within a short time and, on this account, should be made extemporaneously by treating silver cyanid with HCl.

$$\underset{\text{Silver cyanid.}}{AgCN} + HCl = HCN + \underset{\text{Silver chlorid.}}{AgCl}$$

Toxicology.—As poisoning by HCN and the soluble cyanids is so rapid in its effect, very little can be done, but if the patient survives an hour there is some hope. The treatment consists of cold affusions, NH_3, galvanism, stimulants, and atropin. Smith's antidote, composed of ferrous and ferric salts in the presence of alkaline carbonates, may be of service, forming the insoluble Prussian blue, followed by emetics. H_2O_2 has also been proposed.

Uses.—Phthisis, cough, asthma, and gastralgia. Dose, 1 to 3 minims, well diluted.

SILICON

Symbol, Si; Atomic weight, 28; Valence, 4.

This element is widely distributed in nature in the form of *silica*, SiO_2, such as sand, quartz, rock crystal, and flint, almost in pure form. As silicates, combined with various metals, as Mg, Ca, and K, it constitutes the rocks of which the earth's crust is so largely composed. It is also found in certain plants and feathers, to which it gives strength.

Liquid glass is a solution of sodium silicate, which is used for fixing surgical dressings. *Glass* is a mixture of various silicates. When silica is highly heated it fuses, and this fused silicaware can be heated to redness and thrust into ice-water without breaking, and is largely employed for chemical apparatus.

BORON

Symbol, B; Atomic weight, 11; Valence, 3.

This element occurs principally in combination as boric acid, H_3BO_3, and borax, $Na_2B_4O_7.10H_2O$.

Boric Acid (H_3BO_3).—This is a white crystalline substance found naturally in pools of water, which collect the acid from steam jets issuing from earth fissures and passing through it. It is obtained by concentration of the solution.

Properties.—Soluble in 18 parts of H_2O, about 16 parts of alcohol, and 5 parts of glycerin. It is antiseptic. When heated to 100° C. (212° F.) it loses water and is

converted into *metaboric acid;* heated to 160° C. (320° F.) it forms a glass-like mass of *tetraboric acid*, the acid corresponding to borax. Boric acid is obtained by adding HCl to a hot saturated solution of borax.

$$Na_2B_4O_7 + 2HCl + 5H_2O = 4H_3BO_4 + 2NaCl$$

Boric acid is a weak acid, and the alkaline borates show strong alkaline reaction to litmus. When alcohol is added to H_3BO_3 and ignited, it burns with a characteristic green flame.

Medicinal Properties and Uses.—Boric acid is an antiseptic. It is seldom used internally, but when so used, may be given in doses of from 5 to 30 gr.

It is used principally externally as an antiseptic wash, or in the several official preparations containing it, viz., *Glycerite of boroglycerite*, which is made by combining in chemical proportion glycerin and boric acid and adding an equal weight of glycerin. *Boric acid ointment*, containing 10 per cent. of the acid in a mixture of petrolatum and paraffin. It is also contained in the *Liquor antisepticus* and *Cataplasma kaolini*, official preparations intended to replace the largely advertised articles on the market.

Ortho-, Meta-, and Pyro-acids.—*Ortho-acid.*—From the Greek *orthos*, meaning straight, normal, or regular. The regular or common acids are also termed "ortho-acids."

Meta-acids.—A meta-acid is regarded as one molecule

of an *ortho-acid* from which one molecule of water has been removed:

$$\underset{\text{Normal or orthoboric acid.}}{H_3BO_3} - H_2O = \underset{\text{Metaboric acid.}}{HBO_2}$$

Pyro-acids.—If two molecules of an *ortho-acid* are taken and one molecule of water removed, a *pyro-acid* will be produced:

$$2(H_2SO_4) \text{ or } (H_4S_2O_8) - H_2O = \underset{\text{Pyrosulphuric acid.}}{H_2S_2O_7}$$

Borax ($Na_2B_4O_7.10H_2O$).—This sodium salt of boron is found in Clear Lake, Nevada. As stated under Boric Acid, it has an alkaline reaction, soluble in water and glycerin, and, unlike boric acid, is insoluble in alcohol. Its uses and properties are similar to those of boric acid.

SULPHUR

Symbol, S; Atomic weight, 32; Valence, 2, 4, 6.

This element occurs in the free state as a product of past volcanic action in Sicily, Iceland, and California. Large quantities are now obtained in Louisiana, Utah, California, and Nevada. In combination it is found widely diffused in the form of sulphates (gypsum, $CaSO_4.2H_2O$; Epsom salts, $MgSO_4$, $7H_2O$) and sulphids (iron pyrites, FeS_2; galena, PbS; cinnabar, HgS, etc.). It is also found in combination with organic matter in the various proteins, garlic, horse-radish, hair, and in

algæ. During decomposition of these latter substances it is evolved as H_2S. As H_2S it is found as a constituent of some waters.

Properties.—It is a yellow, brittle solid, odorless and tasteless; insoluble in water; soluble in benzene, benzole, chloroform, ether, carbon disulphid, oil of turpentine, and the fatty oils; and melts at 115° C. (239° F.). When melted sulphur is poured into water it forms a plastic mass, one of the allotropic forms of sulphur, which soon changes into the regular form again.

Sulphur is found in commerce in a variety of forms: Brimstone, sublimed sulphur, washed sulphur, and precipitated sulphur.

The crude sulphur when heated is vaporized, and when passed into large cooled chambers condenses, forming the *sublimed* or *flowers of sulphur*. After a time, the condensing chambers becoming warm, the sulphur liquefies and is run into molds, forming *brimstone* or *roll sulphur*. (See page 110.)

Washed sulphur, *Sulphur lotum*, is sublimed sulphur that has been treated with dilute ammonia-water to remove any sulphurous acid, sulphuric acid, and arsenic that may be present. This is the kind that should be used when intended for internal use.

Precipitated sulphur (*milk of sulphur, lac sulphur*) is sulphur, lime, and water boiled together. To the deep orange solution which results HCl is added, and the precipitated sulphur is washed with water and dried. It

is of a lighter color than ordinary sulphur, and when first precipitated is milk white; hence its name.

Medicinal Properties and Uses.—It is alterative, laxative, diaphoretic, resolvent, and antiparasitic. It passes out of the system largely unchanged; the small part that had been combined, as sulphids or H_2S. It enters into the preparation of *sulphur ointment*, 15 per cent. of washed sulphur rubbed up with benzoinated lard. *Compound licorice powder* contains 8 per cent. of it.

Sulphur Dioxid (Formula, SO_2; Molecular Weight, 64; Density, 32).—This is a colorless gas, with a disagreeable, suffocating odor, and, under cold and pressure, can be both liquefied and solidified. Very soluble in water, forming sulphurous acid. It is a disinfectant, reducing and bleaching agent.

Preparation.—It is made whenever sulphur or materials containing it are burned in presence of air.

$$S + {}_2O = SO_2$$

Also by the action of dilute acids upon sulphites:

$$Na_2SO_3 + {}_2HCl = SO_2 + {}_2NaCl + H_2O$$

Sodium sulphite.

This latter reaction is also used as a test for sulphites.

ACIDS OF SULPHUR

Hydrogen Sulphid, *Sulphuretted Hydrogen* (Formula, H_2S; Molecular Weight, 34; Density, 17).—This gas is

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produced by decomposition of organic matter containing sulphur, and also when metallic sulphids are acted upon by dilute acids.

$$\underset{\text{Iron sulphid.}}{FeS} + H_2SO_4 = H_2S + \underset{\text{Iron sulphate.}}{FeSO_4}$$

It is a colorless, poisonous gas, with an odor resembling rotten eggs, soluble in water, and is largely used as a laboratory agent, producing a series of sulphids of various colors.

Sulphurous Acid (Formula, H_2SO_3; Molecular Weight, 82).—This acid is not known in the pure state, but exists only in aqueous solution, the official, which is made by saturating water with SO_2, containing 6 per cent. of SO_2 by weight:

$$SO_2 + H_2O = H_2SO_3$$

It forms two classes of salts, the sulphites and the acid sulphites.

Sulphuric Acid (Formula, H_2SO_4; Molecular Weight, 98).—This acid is made by passing SO_2, HNO_3, steam, and air into large leaden chambers. (The various steps of the equation will be omitted.)

It is a heavy, corrosive liquid; specific gravity, 1.835 (nearly twice that of water); colorless, odorless, and contains 92.5 per cent. by weight of the absolute acid. The dilute acid contains 10 per cent. It has great affinity for water and is a powerful dehydrating agent. When it comes in contact with organic matter it removes the elements of water (the H and O) and leaves a black

residue of carbon. It is commonly called "oil of vitriol." When added to water it evolves great heat. In mixing it with water, the *acid* must be added to the water, and not in the reverse order. *Great care should be exercised in mixing them!* Sulphuric acid produces white eschars upon tissue with which it has been in contact, the edges of which may be dark from its dehydrating property.

Toxicology.—When taken internally, *avoid carbonates*, if possible. Give magnesia, lime, eggs, milk, and bland oils to allay the irritation.

Tests for Sulphuric Acid and Sulphates.—H_2SO_4 and the soluble sulphates produce with solution of barium chlorid, $BaCl_2$, a white precipitate of barium sulphate, $BaSO_4$, insoluble in HCl. The pure acid will char paper or the carbohydrates.

Medicinal Properties and Uses.—Escharotic; also promotes alkaline secretions; tonic and astringent. Used in diarrhea, hemorrhages, night-sweats, and lead-colic. Dose, 2 to 5 minims, well diluted.

Three sulphuric acids are official: *Acidum sulphuricum*, *Acidum sulphuricum dilutum*, and *Acidum sulphuricum aromaticum*, which contains 20 per cent. of H_2SO_4 and is known also as elixir vitriol.

Pyrosulphuric Acid ($H_2S_2O_7$), *Fuming* or *Nordhausen's Sulphuric Acid.*—Made by passing SO_3 into H_2SO_4. It is a thick liquid, very corrosive, and gives off dense fumes of SO_3 when exposed to air.

Thiosulphuric Acid ($H_2S_2O_3$).—This acid does not exist, but its salts do.

Sodium thiosulphate, $Na_2S_2O_3$, improperly called "hyposulphite of soda," is largely used in commerce in paper making. In photography it is used to remove the silver salts that have not been acted upon. It is an excellent antidote for iodin-poisoning. When treated with HCl it behaves like the sulphites, but produces, in addition, a precipitation of sulphur, and this is used as a means of differentiation between the two.

$$\underset{\substack{\text{Sodium}\\\text{thiosulphate.}}}{Na_2S_2O_3} + 2HCl = SO_2 + S + 2NaCl + H_2O$$

Carbon Disulphid (Formula, CS_2; Molecular Weight, 76).—This is a heavy, colorless liquid of a very offensive odor, highly refractive, very volatile, and inflammable. It is made by passing the vapors of S over heated C. It is used as a solvent for fats, rubber, sulphur, iodin, phosphorus, and some alkaloids. Upon a large scale it is used as an insecticide.

PHOSPHORUS

Symbol, P; Atomic weight, 31; Molecular weight, 124; Valence, 3, 5.

This element is found in nature chiefly as the phosphates of calcium, iron, and aluminum. It is found in such mineral combinations in small quantities in all soils and is essential for plant life. It enters the animal economy through the food taken, and is found either

in organic combination or in the bones in the form of calcium and magnesium phosphates. It is also found in the urine.

The element is obtained from its mineral salts by dissolving them in strong H_2SO_4; the resultant compound is heated, then mixed with sand and coke, and the distilled phosphorus collected under water.

Properties.—It occurs as a translucent, slightly yellow solid, and melts under water at 44° C. (111° F.). It has great affinity for O, taking fire when exposed to air. It is luminous in the dark; insoluble in H_2O; slightly soluble in alcohol, fats, and oil; and very soluble in chloroform and CS_2. It combines readily with chlorin, bromin, iodin, sulphur, and metals, forming with the latter phosphids. Phosphorus exists in an allotropic modification, made by exposing common or yellow phosphorus to 260° C. in an atmosphere of inert gases, as CO_2, N, or H, and in this form is known as red phosphorus, the properties of which are widely different from those of the common variety, being non-poisonous, practically insoluble in all liquids, and non-luminous. Phosphorus was principally used in the making of matches, which consisted of dipping wooden splints into melted sulphur, paraffin, and then into a paste of glue and phosphorus, to which some oxidizing agent had been added. As the manufacture of matches by this method produced maxillary necrosis in those working with it, laws have been enacted against its use. In

the so-called "safety match" red phosphorus is used. It is contained upon the surface upon which the match is to be rubbed, combined with antimony pentasulphid. The match proper contains antimony trisulphid, red lead, and potassium chlorate and dichromate. Phosphorus in the elementary state is used in several pharmaceutic preparations, such as pills, elixir, spirits, and phosphorated oil. In domestic use it enters the home in the form of the various "rat pastes."

Toxicology.—*Never give oil or fats*, as phosphorus is soluble in them and would only hasten assimilation. Oil of turpentine (this differs chemically from the oil and fats) has been used, its action depending upon the oxidation of the phosphorus to phosphoric acid. Potassium permanganate in $\frac{1}{10}$ per cent. solution has been successfully used; it converts the phosphorus into H_3PO_4. Copper sulphate, which forms the insoluble copper phosphid or may even coat the phosphorus with metallic copper, can also be given in 5-gr. doses. In all these cases the stomach-pump or emetics must be used to eliminate the poison from the system as soon as possible.

Phosphin, *Phosphoretted Hydrogen* (Formula, PH_3; Molecular Weight, 34).—This is a colorless, ill-smelling gas, analogous in form to NH_3, and is produced whenever phosphorus is boiled with a solution of a caustic alkali or alkaline earth. The gas thus obtained is contaminated with another gas, which is spontaneously inflammable, and this property is frequently ascribed to

the former. Pure PH_3, however, does not inflame at ordinary temperature, though it does when gently heated.

$$3KOH + 4P + 3H_2O = PH_3 + 3KPH_2O_2$$

Potassium hypophosphite.

When added to acids it produces the phosphonium compounds, which are analogous to the ammonium compounds.

ACIDS OF PHOSPHORUS

Phosphoric, phosphorous, hypophosphorous, metaphosphoric, and pyrophosphoric acids.

In considering the acids on page 14 it was stated that, theoretically considered, any acid is divisible into replaceable hydrogen and acid radicle. The replaceable hydrogen is *that* hydrogen that can be replaced by a metal or base, and while all acids contain hydrogen, not all the hydrogen in some acids is capable of replacement. We will find that some of the acids of phosphorus show this exception.

Hypophosphorous Acid (Formula, HPH_2O_2 or H_3PO_2; Molecular Weight, 66).—This acid contains, as will be seen from the second formula, three hydrogens, but only one of these can be replaced. The first formula is the type formula, showing the number of replaceable hydrogens. The acid radicle is (PH_2O_2) with a valence of one, and forms salts as follows:

$Na(PH_2O_2)$ — Sodium hypophosphite.

$Ca(PH_2O_2)_2$ — Calcium hypophosphite.

The acid is made by decomposing a solution of calcium hypophosphite with oxalic acid, or by treating potassium hypophosphite with tartaric acid.

$$Ca(PH_2O_2)_2 + \underset{\text{Oxalic acid.}}{H_2C_2O_4} = 2HPH_2O_2 + \underset{\text{Calcium oxalate.}}{CaC_2O_4}$$

It is official in two strengths, *Acidum hypophosphorosum*, 30 per cent., and *Acidum hypophosphorosum dilutum*, 10 per cent. The acid possesses deoxidizing properties, changing substances brought in contact with it into lower forms.

Tests.—The hypophosphites produce, with solution of silver nitrate, $AgNO_3$, at first, a white precipitate, which becomes brown and finally black, due to reduction of the silver to the metallic state.

If to a solution of a hypophosphite, acidified with HCl, a solution of mercuric chlorid is added, a white precipitate of mercurous chlorid (calomel) is formed, which, upon the addition of more hypophosphite, will be further reduced to mercury.

Medicinal Properties and Uses.—Hypophosphorous acid and the hypophosphites are tonic and supposedly reconstructive. The dose of dilute acid is 10 to 60 minims. The acid is used in the preparation of *syrup of ferrous iodid* as a preserving agent, on account of its deoxidizing property.

Phosphorous Acid ($H_2(PHO_3)$ or H_3PO_3).—As can be seen from the formula, this is a dibasic acid. It pos-

sesses strong deoxidizing properties. The acid and its compounds are of little medical importance.

Phosphoric Acid (Formula, H_3PO_4; Molecular Weight, 98).—This is the most important of the acids of phosphorus. It is found in nature as phosphates in various rocks, principally as calcium phosphate, $Ca_3(PO_4)_2$. It is found in the animal economy as magnesium and calcium in the bones, in the blood as Na_2HPO_4, and in the urine as NaH_2PO_4.

This acid is generally made by the action of dilute HNO_3 upon phosphorus. The official acid exists in two strengths: *Acidum phosphoricum*, containing 85 per cent. by weight of H_3PO_4, and *Acidum phosphoricum dilutum*, containing 10 per cent.

It forms three classes of salts: the first, in which but one of its replaceable H has been substituted by a metal, *e. g.*, NaH_2PO_4; the second, wherein two of the H have been replaced, *e. g.*, Na_2HPO_4, this latter salt being the sodium phosphate of pharmacy and commerce; and the last class, in which all the H is replaced, *e. g.*, Na_3PO_4.

Tests.—H_3PO_4 neutralized with ammonia-water, (NH_4OH), or a phosphate added to a solution of silver nitrate, produces a yellow precipitate, wholly soluble in HNO_3 and NH_4OH.

With *magnesium mixture*, consisting of $MgSO_4$, NH_4Cl, and NH_4OH, a granular white precipitate of $MgNH_4PO_4$ is produced.

Medicinal Properties and Uses.—Phosphoric acid is tonic, alterative, and refrigerant. It is used in dyspepsia, hysteria, diabetes, caries of the bones, night-sweats, catarrhal affections, jaundice, and melancholia. Dose: strong acid, 2 to 5 minims; dilute, 5 to 30 minims, both well diluted.

Pyrophosphoric Acid.—Under Boric Acid (see p. 46) pyro- and meta-acids were defined. This acid is not of great importance, but its sodium salt is extensively used in pharmacy and the arts. Pyrophosphates when added to solutions of silver nitrate produce a white precipitate soluble in NH_4OH, not reprecipitated by HNO_3.

Metaphosphoric acid (HPO_3), also called *glacial phosphoric acid*, because it exists in glass-like masses. It differs from phosphoric and pyrophosphoric acids by coagulating albumin and acting like a poison, while the others are practically harmless.

HALOGENS

These consist of the four elements—chlorin, iodin, bromin, and fluorin—and have properties very much in common. They are derived from compounds found in sea-water; hence the name "halogen," signifying a generator of salt. They all have the valence of 1, but also exist, in some of their compounds, with valencies of 3, 5, and 7. They all combine with hydrogen, producing *binary* acids, which are colorless gases soluble in

water, and in this form they exist in commerce. They combine directly with most metals, forming chlorids, iodids, bromids, and fluorids. Chlorin and fluorin are gases. Iodin is a solid. Bromin is a liquid at ordinary temperature. In the gaseous condition each possesses a distinctive color, has a disagreeable and irritating odor, and is a powerful disinfectant.

CHLORIN

Symbol, Cl; Atomic weight, 35.

Occurrence in Nature.—Found largely as sodium chlorid, NaCl, as common salt, rock salt; in salt lakes, seas, and oceans; also as the chlorids of potassium, magnesium, and calcium.

Preparation.—Made commonly by heating black oxid of manganese with HCl or H_2SO_4:

$$\underset{\text{Manganese dioxid.}}{MnO_2} + 4HCl = \underset{\text{Manganese chlorid.}}{MnCl_2} + 2Cl + 2H_2O \text{ or}$$

$$MnO_2 + 2NaCl + 2H_2SO_4 = 2Cl + \underset{\text{Manganese sulphate.}}{MnSO_4} + Na_2SO_4 + 2H_2O$$

Chlorin is also produced by the action of HCl or H_2SO_4 upon the so-called "chlorid of lime," or bleaching powder, which is a mixture of $CaCl_2$ and $Ca(ClO)_2$.

$$\underset{\text{Chlorid of lime.}}{CaCl_2.Ca(ClO)_2} + 4HCl = 4Cl + 2CaCl_2 + 2H_2O$$

On a commercial scale, chlorin is now extensively made by the electrolysis of common salt.

Properties.—It is a yellowish-green gas (hence the name, from *chlorus*, green), with a disagreeable taste and suffocating odor, about two and a half times heavier than air, very soluble in water, forming with it *chlorin-water*. Under pressure it is converted into a yellowish-green liquid, and is now obtainable in this form in steel cylinders. It combines with all elements, but with some only indirectly, as O, N, and C. Excepting fluorin, it is the most powerful of the *halogens*, liberating iodin and bromin from their compounds. The combination of chlorin with some substances is very energetic, accompanied by heat and, in some instances, light. It has great affinity for hydrogen and will decompose compounds containing it, to rob them of their hydrogen. It is a powerful disinfecting and bleaching agent. Its action as a bleaching agent is indirect; when used for these purposes, moisture must be present. Its action depends upon the formation of *nascent* oxygen by the chlorin removing the hydrogen from the H_2O; this *nascent* oxygen, being more energetic, oxidizes or combines with certain elements contained in these compounds.

Liquor Chlori Compositus, U. S. P., *Chlorin-water.*—This is made by treating potassium chlorate with HCl and adding water carefully to the generated Cl. It is an unstable compound, combining with the hydrogen of the H_2O, liberating oxygen. It should be freshly made when wanted.

Hydrochloric Acid, *Muriatic Acid* (Formula, HCl; Molecular Weight, 36).—This acid is obtained by the action of H_2SO_4 upon a chlorid, usually NaCl:

$$2NaCl + H_2SO_4 = 2HCl + Na_2SO_4$$

It is a colorless gas, with a penetrating odor and irritating to inhale. Its great affinity for H_2O is shown by the formation of a white cloud when the gas comes in contact with the moisture in the atmosphere. The gas dissolved in water is the hydrochloric acid of the U. S. P., and contains nearly 32 per cent. by weight of HCl. The dilute acid contains 10 per cent. HCl is found as a constituent of the gastric juice, the exact quantity being somewhat in doubt, but approximately 0.2 per cent.

Medicinal Properties and Uses.—Tonic, refrigerant, antiseptic, irritant, and poisonous. Given before meals, it checks the flow of gastric juice and diminishes acidity. Given two or three hours after food, it increases the acidity, increases the saliva, checks fermentation, and allays thirst. Dose: strong acid, 2 to 5 minims; dilute, 5 to 30 minims, both well diluted.

Tests.—With the exception of silver, mercurous and lead chlorids, all other chlorids are soluble.

HCl or a chlorid added to silver nitrate, $AgNO_3$, produces a white precipitate of silver chlorid, AgCl, soluble in NH_4OH and reprecipitated upon the addition of HNO_3. This reprecipitation by HNO_3 distinguishes

chlorids from all other substances, producing white precipitates with silver nitrate, soluble in NH_4OH.

Nitrohydrochloric Acid, *Aqua Regia; Nitromuriatic Acid.*—When HCl and HNO_3 are mixed, chemical action takes place, liberating Cl and chlorin derivatives. This acid is remarkable for its solvent action upon gold and platinum, due to the free chlorin contained in it. Neither of the acids entering into its manufacture has any effect upon these metals. A dilute acid is also official.

Medicinal Properties and Uses.—Tonic, antiseptic, astringent, escharotic, and cholagogue. It is used in intestinal indigestion with diarrhea, chronic hepatitis, jaundice, scrofula, whooping-cough, and bronchitis; and externally as an escharotic. Dose: strong acid, 2 to 5 minims; dilute acid, 5 to 30 minims, both well diluted.

Toxicology.—Same as under Sulphuric Acid.

IODIN

Symbol, I; Atomic weight, 126.

This is found in nature combined as the iodids of sodium and potassium.

It is contained in sea-water, from which it is taken up by plants. Its chief source of supply is from the ashes of sea-weeds, called *kelp*. By washing these ashes the soluble constituents contained in them are dissolved, and after removal of other substances contained in the solution, and the latter evaporated to dryness, the iodin

is obtained by a process similar to obtaining Cl, by treating the residue with MnO_2 and H_2SO_4.

$$2KI + MnO_2 + 2H_2SO_4 = 2I + K_2SO_4 + MnSO_4 + 2H_2O$$

Potassium iodid.

It is also obtained from the mother liquor of Chili saltpeter, $NaNO_3$.

It is also found in small quantities in the animal economy as a constituent of the thyroid gland.

Properties.—Iodin is a crystalline substance, possessing a metallic luster, a characteristic odor, and a sharp, biting taste. When heated it gives off violet vapors. It is only slightly soluble in water. The solubility is greatly increased by the addition of binary halogen salts. It is soluble in alcohol, ether, carbon disulphid, and chloroform. Iodin possesses antiseptic properties, and today a solution of it in alcohol replaces the antiseptics formerly used in surgical operations. It stains tissues brown. These stains can be removed by NH_4OH or sodium thiosulphate, $Na_2S_2O_3$. It is an irritant poison, and the best antidote is sodium thiosulphate or starch, followed by emetics.

Tests for Iodin and Iodids.—Iodin turns blue with boiled starch. Iodids with soluble lead salts produce a yellow precipitate of lead iodid, PbI_2. Iodids with mercuric salts produce a red precipitate of mercuric iodid, HgI_2, soluble in excess of either reagent.

Chlorin-water treated with iodids liberates the iodin,

and, if carbon disulphid or chloroform is added and shaken, the lower layer will be turned violet.

Medicinal Properties and Uses.—Iodin is antiseptic, counter-irritant, and alterative, rapidly absorbed by mucous membranes and eliminated in urine, saliva, milk, and by the intestinal and nasal mucous membranes. It is mostly used externally for enlarged glands, abscesses, swollen joints, and for its counter-irritant properties in general.

Official Preparations Containing Iodin.—*Liquor iodi compositus*, Lugol's solution, contains 5 per cent. of iodin and 10 per cent. of potassium iodid dissolved in 100 parts of water. Tincture of iodin contains 7 per cent. of iodin and 5 per cent. of potassium iodid dissolved in sufficient alcohol to make 100 parts. *Unguentum iodi* contains 4 per cent. each of iodin and potassium dissolved in glycerin and incorporated with sufficient ointment base to make 100 parts.

Hydriodic Acid (Formula, HI; Molecular Weight, 127).—This, as noted under the *halogens*, is a gas dissolved in water constituting the HI of pharmacy, which is made by adding tartaric acid to potassium iodid in the presence of alcohol, and, after cooling, separating the acid from the *cream tartar*, or potassium bitartrate. It contains 10 per cent. by weight of the absolute acid, and is principally used to make the syrup of hydriodic acid, which contains 1 per cent. by weight of absolute HI. The acid readily decomposes.

This decomposition is somewhat retarded by adding hypophosphorous acid.

BROMIN

Symbol, Br; Atomic weight, 80.

This element, like iodin, is found in sea-water and in a large number of mineral waters as magnesium, calcium, and sodium bromids, and is prepared like chlorin and iodin, by treating the dried bromids with MnO_2 and H_2SO_4 or with chlorin.

$$\underset{\text{Magnesium bromid.}}{MgBr_2} + 2Cl = \underset{\text{Magnesium chlorid.}}{MgCl_2} + 2Br$$

It is a reddish-brown liquid, three times as heavy as water, giving off suffocating reddish-brown vapors of an irritating odor. It is slightly soluble in water; like iodin, its solubility is increased by addition of the binary halogen salts. It is freely soluble in alcohol, ether, carbon disulphid, and chloroform. It is a bleaching agent, disinfectant, and a corrosive poison.

Toxicology.—Ammonia-water well diluted may be given. Sodium thiosulphate is of service. Demulcent drinks to allay irritation. External heat, atropin, and strychnin.

Medicinal Properties.—Bromin by itself is never given internally, but its various compounds are extensively used, and will be considered under their individual heads. Externally, it is rarely used as a corrosive irritant and for glandular enlargements.

Hydrobromic Acid (Formula, HBr; Molecular Weight, 81).—Made by treating bromin under water with H_2S until the brown color of Br has disappeared.

$$10Br + 2H_2S + 4H_2O = 10HBr + H_2SO_4 + 1S$$

The liquid is filtered from the precipitated sulphur, and separated from the H_2SO_4 by distillation. The dilute acid, which is official, contains 10 per cent. by weight of HBr.

Medicinal Properties.—Sedative, narcotic; in small doses, stimulant similar to potassium bromid, but does not depress like it. Dose: ½ fluidram, in syrup or water.

Tests for HBr and Bromids.—Chlorin-water or HNO_3 added to bromids liberate Br. If shaken with carbon disulphid or chloroform the lower layer will be turned brown.

Silver nitrate added to bromids produces a white precipitate, only slightly soluble in NH_4OH (difference from chlorids).

FLUORIN

Symbol, F; Atomic weight, 19.

This element is found as fluorspar, CaF_2, also in the enamel of the teeth and in the bones of mammals. It is a yellowish gas, of an irritating, suffocating odor; it is a powerful oxidizing agent, greater than any other element; and it combines with all elements except oxygen, with which it combines neither directly nor indirectly.

Hydrofluoric acid is a colorless gas, obtained by the action of H_2SO_4 upon calcium fluorid:

$$CaF_2 + H_2SO_4 = 2HF + CaSO_4.$$

Hydrofluoric acid is used to etch glass. The glass is covered with paraffin or wax and scratched with a sharp needle. It is then exposed to the hydrofluoric gas, or to a solution of it in water, kept in a rubber or gutta-percha container.

After removal of the protective, the exposed surface will be found to be etched.

ACIDS OF THE HALOGENS

Chlorin.	Bromin.	Iodin.	Fluorin.
HCl, Hydrochloric acid.	HBr, Hydrobromic acid.	HI, Hydriodic acid.	HF, Hydrofluoric acid.
$HClO$, Hypochlorous acid.	$HBrO$, Hypobromous acid.	HIO, Hypoiodous acid.	
$HClO_2$, Chlorous acid.	$HBrO_2$, Bromous acid.	HIO_2, Iodous acid.	
$HClO_3$, Chloric acid.	$HBrO_3$, Bromic acid.	HIO_3, Iodic acid.	
$HClO_4$, Perchloric acid.	$HBrO_4$, Perbromic acid.	HIO_4, Per-iodic acid.	

METALLIC ELEMENTS

We have thus far considered only the *non-metallic elements*. We will now take up the more important metallic elements. For convenience of study the metals will be divided into certain groups which have properties very much in common.

The metals are divided into two classes: the "light metals," having a specific gravity (Sp. G.) from 0.6 to 4, and the "heavy metals," Sp. G. ranging from 6 to 22.5. Each class is further divided into other groups.

LIGHT METALS

Alkali metals.	Alkaline earth metals.	Earth metals.
K, Na, Li, (NH_4). Oxids, carbonates, and most soluble salts.	Ba, Ca, Sr, and Mg. Soluble oxids. Insoluble carbonates, phosphates, and sulphates (except Mg).	Al. Insoluble oxids, but its chemical behavior leans strongly toward the iron group.

HEAVY METALS

Iron group.	Lead group.	Arsenic group.
Fe, Co, Ni, Mn, Zn, Cr. Sulphids soluble in dilute acids.	Cd, Pb, Cu, Bi, Ag. Sulphids insoluble in dilute acids. Sulphids insoluble in ammonium sulphid.	As, Sb, Sn, Au, Pt, Mo. Sulphids insoluble in dilute acids. Sulphids soluble in ammonium sulphid.

Metals possess properties which distinguish them from the non-metals. All have a metallic luster, with the

exception of iodin, the non-metals do not possess this. They are conductors of heat and electricity. They range in color from silver white to the yellow of gold. Copper is red. At ordinary temperature they are solid, except mercury, which is the only liquid metal. All can be fused by heat and some even distilled, without changing their metallic nature. When mixed with other metals they form *alloys* and still retain their metallic nature. When mercury constitutes one of the ingredients of an alloy it is termed an *amalgam.* Metals treated with non-metals lose their metallic properties, but in a few instances, as in the compounds of iron and sulphur, the luster is retained. Metals replace hydrogen in acids, forming salts.

Salts, which have already been referred to on page 17, were described as acids in which part or all of the replaceable hydrogen has been exchanged for a metal or *basic radicle.* They are divided into *normal, acid, basic,* and *double* salts.

Normal Salts.—A normal salt is one in which all the replaceable hydrogen of the acid has been exchanged for a metal or base; for example, if all the hydrogen in H_2SO_4 was replaced by sodium, Na_2SO_4 would be produced. From its chemical behavior we should expect a normal salt to have a neutral reaction toward *litmus.* If both the acid and the metal or base are of equal intensity, such will be the case. Sodium sulphate, the example just shown, will be found neutral, as in this

instance both the acid and the metal are of equal intensity. Sodium carbonate, Na_2CO_3, which is theoretically derived from H_2CO_3, is chemically a normal salt, because all the hydrogen of the H_2CO_3 is replaced by sodium, but, as has already been shown, H_2CO_3 is a weak acid, and, the metal possessing strong alkaline properties, the salt will possess alkaline reaction toward litmus. In aluminum sulphate, $\overset{'''}{Al_2}(\overset{''}{SO_4})_3$, we have an entirely different condition. The formula shows that there is no replaceable hydrogen left; hence, chemically, it is a normal salt; but as aluminum is a weak base, combined with a strong acid, the salt possesses acid properties toward litmus and other substances.

Acid Salts.—In this case only part of the replaceable hydrogen has been exchanged by a metal or basic radicle. If but one H in H_2SO_4 is replaced by Na, $NaHSO_4$ is formed. This is called an *acid* or *bisalt.* As these salts may, in reality, be considered as partly acid, we could infer that they should possess acid reactions; and this is generally true. If, on the other hand, a weak acid were used with a strong base or metal, the salt would have an alkaline reaction, as in sodium bicarbonate, $NaHCO_3$, in which we have the strong metal, Na, with the weak acid H_2CO_3.

Basic or Subsalts.—These contain a greater portion of base than is required to make a *normal salt.* There is no fixed rule which will apply to all cases. Several views are entertained. The most common is that they

are combinations of normal salts to which an oxid of a metal has been added.

$$\underset{\text{Lead acetate.}}{Pb(C_2H_3O_2)_2} + \underset{\text{Lead oxid.}}{PbO} = \underset{\text{Basic acetate of lead or lead subacetate.}}{Pb_2O(C_2H_3O_2)_2}$$

Another theory is that they may be regarded as metallic hydroxids, the hydroxyl, (OH), having been replaced by acid radicles. Bismuth hydroxid is $Bi(OH)_3$; replace one of the (OH) by the acid radicle (NO_3), and the resulting compound is $Bi(OH)_2NO_3$.

Double Salts (Also Called *Multiple Salts*).—In these salts the replaceable hydrogens of the acid have been exchanged by two or more metals or bases. If in H_3PO_4 two H are replaced by Mg and the other by (NH_4) magnesium ammonium phosphate will be formed, $Mg(NH_4)PO_4$. Tartaric acid has the formula of $H_2(C_4H_4O_6)$; if one H is replaced by Na and the other by K the double salt of potassium and sodium tartrate, commonly called *Rochelle salts*, $KNaC_4H_4O_6$, will be formed.

ALKALI METALS

These are K, Na, Li, and the compounds of ammonium. They possess properties showing a great resemblance to one another in both their chemical and physical behavior. They are soft; silver white in appearance; univalent, that is, have but one bond; and when thrown upon water decompose it, liberating

hydrogen. They must be preserved under coal oil or the hydrocarbons. Their hydroxids and carbonates, except lithium carbonate, are soluble in water and possess a strong alkaline reaction; they saponify fats and completely neutralize acids. Since the salts of these metals are so similar, they will be treated together, except in cases where special distinctions will be noted.

POTASSIUM AND SODIUM

Potassium (Symbol, K; Atomic weight, 39; Valence, 1) is found in nature as the nitrate and chlorid, in feldspar and in plants, from which it is extracted as the carbonate from the ash. As sulphate and chlorid it is found in enormous quantities in the Strassfurt mines. Medicinally, the potassium compounds depress the heart and lower muscle activity.

Sodium (Symbol, Na; Atomic weight, 23; Valence, 1) is found principally in the form of the chlorid, as rock-salt, common salt, and also dissolved in water. It is also found, as the nitrate, in Chili saltpeter.

Potassium Hydroxid (KOH; Molecular Weight, 56) **and Sodium Hydroxid** (NaOH; Molecular Weight, 40). —Caustic soda and potassium. These are made by boiling dilute solutions of their respective carbonates with calcium hydroxid. The hydroxid is separated from the insoluble calcium carbonate, $CaCO_3$, by de-

cantation, evaporated in silver vessels, fused, and poured into pencil-shaped molds.

$$K_2CO_3 + Ca(OH)_2 = 2KOH + CaCO_3 \text{ or}$$
$$Na_2CO_3 + Ca(OH)_2 = 2NaOH + CaCO_3$$

They are hard, brittle, white solids; deliquescent; absorb CO_2 from the atmosphere; very soluble in water and alcohol; highly caustic and escharotic.

Toxicology.—The treatment, which is similar to ammonia-water and all caustic alkalis or alkaline earths, is to neutralize by giving vegetable acids, such as vinegar or lemon-juice, followed by bland fats or oils or demulcents to allay irritation.

Medicinal Properties and Uses.—Externally, in the solid form or strong solution, as an escharotic. Internally, highly diluted, as an antacid; in acid dyspepsia, before meals, stimulates acid secretion; at the end of or after meals neutralizes the excessive acidity of the gastric juice already secreted. Also alkalinizes the urine and checks saliva. The official solution of each of these hydroxids contains 5 per cent. of absolute hydroxid and is given in doses of 5 to 30 minims, well diluted.

Potassium Carbonate, *Salts of Tartar* (K_2CO_3; Molecular Weight, 138) **and Sodium Carbonate** (Na_2CO_3; Molecular Weight, 106).—Potassium carbonate is obtained from wood ashes by the process of lixiviation. It is a white deliquescent salt, with strong basic prop-

erties. Sodium carbonate of pharmacy contains 1 molecule of water of crystallization, and has the formula of $Na_2CO_3.H_2O$. In commerce this salt occurs in the form of large crystals, more commonly called *sal soda* or *washing-soda*, containing 10 molecules of water of crystallization, $Na_2CO_3.10H_2O$.

Medicinal Properties.—The carbonates of these metals are not often used except as antacids, well diluted, in doses of 5 to 20 gr.

Potassium Bicarbonate ($KHCO_3$; Molecular Weight, 100) **and Sodium Bicarbonate** ($NaHCO_3$; Molecular Weight, 84).—These are made by passing CO_2 into solutions of their respective carbonates.

They are less alkaline than the carbonates, and are principally used as antacids in doses of 5 to 40 gr. Sodium bicarbonate is combined with sugar and nutmegs to form the *troches of sodium bicarbonate*, each containing nearly 3 gr. of it.

Potassium Sulphate (K_2SO_4; Molecular Weight, 174) **and Sodium Sulphate** ($Na_2SO_4.10H_2O$; Molecular Weight, 322).—The former exists in nearly all the fluids of the body and in the urine. Sodium sulphate, also known as "Glauber's salts," is made by the action of H_2SO_4 upon NaCl, and is usually obtained as a by-product in the manufacture of HCl.

$$2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl$$

Medicinal Properties.—Sodium sulphate is a hydragogue cathartic, and is given in doses of 2 to 8 drams.

Sodium Thiosulphate (Formula, $Na_2S_2O_3.5H_2O$; Molecular Weight, 248).—This compound, which is improperly called *hyposulphite of soda* and even "hypo," is largely used in photography. It is useful as an antidote to iodin-poisoning, and is used in paper-making to neutralize the chlorin used as a bleaching agent.

Medicinal Properties.—Alterative, resolvent, and antifermentative. Dose, from 5 to 30 gr. As an antidote, the dose depends upon the amount of poison taken.

Sodium Phosphate (Formula, $Na_2HPO_4.12H_2O$; Molecular Weight, 358).—It was stated under Phosphoric Acid (see p. 57) that it was possible to have three sodium phosphates: Na_3PO_4; Na_2HPO_4, the official sodium phosphate and which is found in the blood; and NaH_2PO_4, found in the urine.

The official sodium phosphate is made by neutralizing with sodium carbonate, Na_2CO_3, a solution of acid calcium phosphate, which is obtained by the action of H_2SO_4 upon calcium phosphate, and the evaporation of the solution removed from the precipitated calcium phosphate.

Medicinal Properties.—Alterative in doses of 20 to 30 gr. Purgative and hepatic stimulant in doses of 2 to 6 drams.

Sodium phosphate is soluble in about 5.5 parts of water. Its solubility is greatly increased by the addition of citric acid. The *Liquor sodii phosphatis compositus* is practically a 100 per cent. solution of it, due to

the formation of more soluble compounds. The *granular effervescent sodium phosphate* contains 20 per cent. of the dried salt combined with tartaric and citric acids, with sodium bicarbonate. *Sodium phosphate exsiccated* is the crystallized salt heated, not above 100° C., until it no longer loses water. It is two and a half times more active than the regular sodium phosphate.

Sodium Sulphite (Formula, $Na_2SO_3.7H_2O$; Molecular Weight, 252).—Made by neutralizing a solution of Na_2CO_3 with SO_2. When an excess of SO_2 is used, sodium bisulphate is formed. Sodium sulphite exists in crystalline form without odor, while sodium bisulphite gives off the odor of SO_2.

Medicinal Properties.—Antifermentative in doses of 5 to 30 gr.

Sodium pyrophosphate (Formula, $Na_4P_2O_7.10H_2O$; Molecular weight, 446) is produced by heating sodium phosphate to a low red heat.

$$2Na_2HPO_4 = Na_4P_2O_7 + H_2O$$

Medicinally, it is similar to the phosphate.

Potassium Nitrate, *Saltpeter* (KNO_3; Molecular Weight, 101) **and Sodium Nitrate,** *Chili Saltpeter* ($NaNO_3$; Molecular Weight, 85).—These salts are found native, are purified by crystallization, and are the principal sources of HNO_3.

Medicinal Properties.—Refrigerant and diuretic in doses of 5 to 15 gr. Purgative in doses of 2 to 6 drams.

Sodium Nitrite (KNO_2; Molecular Weight, 85) **and Potassium Nitrite** ($NaNO_2$; Molecular Weight, 69).—These are made by heating potassium or sodium nitrate with metallic lead, which removes the oxygen. It is used in the preparation of the official *spirits of nitre.*

Medicinal Properties.—Sodium nitrite is a cardiac depressant and antispasmodic, similar in action to amyl nitrite and nitroglycerin, but milder and more uniform. Dose, 1 to 5 gr.

Sodium Chlorid, *Common Salt* (Formula, NaCl; Molecular Weight, 58).—This substance is the principal sodium compound, and is largely used as a source of the other sodium compounds. It is found in all parts of the animal economy, the total quantity in the body being estimated as 110 grams. It aids absorption of albuminoid substances by osmosis. It furnishes the HCl of the gastric juice through decomposition. It is eliminated by the urine as the double chlorids of sodium and potassium, and also by the perspiration.

This elimination is decreased in febrile conditions.

When pure, it is non-hygroscopic and, as commonly found, contains calcium and magnesium chlorids, which absorb moisture from the air, becoming damp and caking.

Potassium Iodid (KI; Molecular Weight, 165) **and Sodium Iodid** (NaI; Molecular Weight, 149).—Made by the action of iodin upon the respective hydroxids of potassium and sodium, and fusing the mixed iodid and

iodate with charcoal, dissolving in water and crystallizing:

$$6KOH + 6I = 5KI + \underset{\text{Potassium iodate.}}{KIO_3} + 3H_2O$$

and

$$KIO_3 + 3C = KI + 3CO$$

Medicinal Properties.—Alterative, stimulant, and absorbent. Dose, 2 to 30 gr.

Potassium Bromid (KBr; Molecular Weight, 119) **and Sodium Bromid** (NaBr; Molecular Weight, 103).—These compounds are made by a method similar to that for iodids, substituting Br for I.

Medicinal Properties.—Sedative, hypnotic, anesthetic, narcotic, and anaphrodisiac, in 10- to 60-gr. doses. As an antidote to strychnin-poisoning in doses of 3 to 4 drams.

Sodium Hypophosphite ($Na(PH_2O_2).H_2O$; Molecular Weight, 106) **and Potassium Hypophosphite** ($K(PH_2O_2)$; Molecular Weight, 104).—The hypophosphites of these metals are made by interaction of the solutions of their respective carbonates with calcium hypophosphites and gently evaporating the solution separated from the insoluble calcium carbonate.

Medicinal Properties.—Their use is believed to depend upon the phosphorus contained in them. They are used in scrofulous affections, bronchitis, and depleted nerve power. The dose is from 5 to 30 gr. These hypophosphites are contained in the various official syrups of the

hypophosphites and in *emulsion cod-liver oil with hypophosphites.*

Potassium Chlorate ($KClO_3$; Molecular Weight, 122).—This compound is made by the action of Cl on heated solution of KOH.

$$6Cl + 6KOH = 5KCl + KClO_3$$

Also by oxidizing by electrolysis a solution of potassium chlorid.

It is a white crystalline substance, a powerful oxidizing agent, and must not be triturated, in the dry condition, with organic matter. Yields chlorin upon addition of strong acids.

Medicinal Properties.—Alterative, oxidizant, astringent, and diuretic. Dose, 5 to 20 gr. It enters into the preparation of *troches of potassium chlorate*, which contain about $2\frac{1}{2}$ gr. each.

Salts of Potassium and Sodium with Organic Acids.—Acetic, benzoic, citric, tartaric, and salicylic acid, when acted upon by the carbonates of sodium, potassium, ammonium, or lithium, produce the corresponding salts. These will be considered under the Organic Acids.

Tests of Potassium and Sodium.—*Potassium.*—If to a solution of a potassium salt a solution of tartaric acid is added until acid in reaction, and a small amount of alcohol is added, a granular white precipitate of cream of tartar is produced.

Potassium compounds when held in a non-luminous

flame impart a violet color to it, not obscured by blue glass.

Sodium.—As practically all sodium compounds are soluble, no test by precipitation can be carried out, as with the other metals. The compounds of this metal impart to the non-luminous flame a yellow color, obscured by blue glass.

LITHIUM

Symbol, Li; Atomic weight, 7.

Lithium is found, in very small quantities, in various waters. It is also found as the carbonate and phosphate. It is characterized by the crimson color which it gives to the non-luminous Bunsen flame. The carbonates and phosphates are insoluble and, in this respect, differ from the other metals of the alkalis, Na and K.

The salts of lithium which are official are the benzoate, bromid, carbonate, citrate, and salicylate.

Medicinally, they are supposed to possess diuretic properties and to be solvents for calculi.

AMMONIUM COMPOUNDS

The salts of the radicle ammonium (NH_4) possess both physical and chemical properties quite similar to those of potassium and sodium.

Ammonium Hydroxid, *Ammonia-water*, NH_4OH.—(See page 33.)

Ammonium Carbonate, *Sal Volatile* (Formula, $NH_4HCO_3.NH_2NH_4CO_2$).—This is not the normal car-

bonate, the formula of which would be $(NH_4)_2CO_3$, but is a mixture of acid ammonium carbonate and ammonium carbamate, obtained by sublimation (see page 110) of a mixture of ammonium sulphate and calcium carbonate. It is a volatile salt, with the odor of ammonia, and is used principally in the preparation of *spirits of ammonia aromatic.*

Medicinal Properties.—Cardiac stimulant, expectorant, and rubefacient. Used in bronchitis, pneumonia, and faintness. Dose, 2 to 3 gr.

Ammonium Chlorid, *Sal Ammoniac* (NH_4Cl; Molecular Weight, 53).—Made by neutralizing NH_4OH with HCl, and purifying.

Medicinal Properties.—Stimulant, irritant, and expectorant. Dose, 3 to 20 gr. It is contained in the *troches of ammonium chlorid*, which contain $1\frac{1}{2}$ gr. each, combined with extract of licorice.

Ammonium bromid (NH_4Br) and **ammonium iodid** (NH_4I) are similar, in both their chemical and medicinal properties, to those of sodium and potassium.

Ammonium Nitrate (NH_4NO_3; Molecular Weight, 80).—This is made by neutralizing NH_4OH with HNO_3, evaporating the solution, and allowing the salt to crystallize. It is used principally in the preparation of nitrous oxid, or laughing-gas, N_2O.

Tests of the Ammonium Compounds.—The ammonium compounds differ from those of the alkalis by being volatilized under direct heat.

If to a solution of an ammonium salt a caustic alkali is added and heat is applied, the odor of NH_3 will be detected, and the NH_3 given off will turn moistened red litmus-paper blue.

ALKALINE EARTH METALS

These are Ca, Ba, Sr, and Mg. They all have a valence of 2. Their salts are characterized by their oxids and hydroxids, have an alkaline reaction, and are only slightly soluble. Their carbonates, phosphates, and sulphates are insoluble, except magnesium sulphate, which is soluble.

CALCIUM

Symbol, Ca; Atomic weight, 40; Valence, 2.

This is found as the carbonate, $CaCO_3$, in limestone, marble, chalk, and oyster shells; as the sulphate, $CaSO_4$, in gypsum and alabaster; and as phosphate, $Ca_3(PO_4)_2$, in various rocks and bones.

Calcium Oxid, *Lime* (CaO; Molecular Weight, 56).—Prepared by *calcination*, that is, by highly heating a carbonate to drive off the CO_2.

$$CaCO_3 = CaO + CO_2$$

Lime is a white, odorless, infusible substance which, when exposed to air, gradually absorbs moisture and CO_2, becoming slaked, with the formation of the carbonate. Upon the addition of water it evolves great heat, forming the hydroxid or *milk-of-lime*, $Ca(OH)_2$, the solution of which is known as *lime-water*. Lime-water readily

absorbs CO_2, forming the carbonate, becoming useless. Hence, lime-water should be freshly made.

Medicinal Preparations.—*Liquor calcis*, or lime-water, is a saturated solution of $Ca(OH)_2$ in water. Syrup of lime contains a larger amount of lime than lime-water, due to the sugar forming a more soluble compound with it. The *Linimentum calcis*, or *carron oil*, is made by mixing equal volumes of linseed oil and lime-water, and is used in burns.

Calcium Carbonate ($CaCO_3$; Molecular Weight, 100).—This is official in two forms: the *Creta preparata*, or prepared chalk, a constituent of *chalk mixture;* and precipitated chalk, made by adding a soluble carbonate to calcium chlorid, and is principally used as a dentifrice:

$$Na_2CO_3 + CaCl_2 = CaCO_3 + 2NaCl$$

Calcium Hypophosphite ($Ca(PH_2O_2)_2$; Molecular Weight, 170).—Made by heating phosphorus with milk-of-lime until phosphin, PH_3, is no longer evolved.

$$8P + 3Ca(OH)_2 + 6H_2O = 3Ca(PH_2O_2)_2 + 2PH_3$$

It is used to prepare the other hypophosphites and hypophosphorous acid.

Medicinal Properties, Uses, and Preparations.—These are similar to those of sodium and potassium.

Chlorinated Lime, *Bleaching Powder.* (See page 59).—This compound is made by passing chlorin gas over slaked lime.

$$2Ca(OH)_2 + 4Cl = \underset{\text{Chlorinated lime.}}{Ca(ClO)_2 \cdot CaCl_2} + 2H_2O$$

It is a powerful disinfectant and bleaching agent, with an odor of chlorin, and evolves the latter upon the addition of acids. It is used pharmaceutically for the preparation of *Liquor sodæ chlorinatæ* (Labarraque's solution) by treating it with a solution of sodium carbonate.

Calcium Sulphate ($CaSO_4.2H_2O$).—This is found native as gypsum, and, when heated, loses it water of crystallization, forming "plaster Paris"; used to fix surgical dressings and making casts. When water is added to it, it assumes its hydrated crystalline state.

Calcium Bromid ($CaBr_2$) **and Calcium Chlorid** ($CaCl_2$). —These compounds are prepared by neutralizing their respective acids with calcium carbonate. They are highly deliquescent salts. The properties of the former are identical with those of sodium and potassium. The latter is used in drying, gases, and, internally, as a resolvent, in doses of 10 to 20 gr.

Tests for Calcium.—Soluble salts of calcium produce a granular precipitate with ammonium oxalate, $(NH_4)_2C_2O_4$, insoluble in acetic acid. It colors a non-luminous flame a yellowish red.

STRONTIUM

Symbol, Sr; Atomic weight, 87.

This metal is found principally as carbonate and sulphate.

The official salts are the bromids, iodids, and salicyl-

ates, and they possess properties similar to those of the alkalis with corresponding acids.

Strontium salts tinge a non-luminous flame a crimson color.

Toxicology.—The nitrate of strontium, which is principally used in pyrotechnics, is poisonous; and as the metals of this group form insoluble carbonates, phosphates, and sulphates, the sodium salts of these acids can be used, followed by emetics. Magnesium sulphate can also be used.

BARIUM

Symbol, Ba; Atomic weight, 137.

Barium is found as both the carbonate and the sulphate.

Barium Dioxid or Peroxid (BaO_2; Molecular Weight, 169).—This compound, which is so extensively used in the preparation of the other dioxids and H_2O_2, *q. v.*, is made by heating the oxid to red heat.

Barium Chlorid ($BaCl_2$; Molecular Weight, 207).—This is made by neutralizing $BaCO_3$ with HCl, and is used as a reagent in the chemical laboratory.

Barium salts are poisonous, and their antidote is sodium or magnesium sulphate, followed by emetics or the compounds which will produce insoluble salts, as stated under the Toxicology of Strontium.

Tests.—Sulphuric acid or soluble sulphates produce a white precipitate of $BaSO_4$, insoluble in HCl. This is

not only true of barium compounds, but other metals give similar results.

Barium compounds impart a green color to a non-luminous flame.

MAGNESIUM

Symbol, Mg; Atomic weight, 24; Valence, 2.

This element is found as the carbonate, sulphate, and silicate. The metal is of a bluish-white color. When it burns it produces an intensely brilliant flame, and is used in the composition of "flash-light" powders.

Magnesium Oxid, *Calcined Magnesia; Magnesia Alba* (MgO; Molecular Weight, 40).—This compound, following the general methods of forming oxids, is made by *calcination* of magnesium carbonate.

$$MgCO_3 = MgO + CO_2$$

It is a very light, white powder, very slightly soluble in water, to which it imparts an alkaline reaction, due to the formation of hydroxid, $Mg(OH)_2$, commonly called, "milk of magnesia." Another variety, *Magnesia ponderosa*, or heavy magnesia oxid, is also official.

Medicinal Properties and Uses.—Antacid and cathartic in doses of 5 to 60 gr. It is also used as a dusting-powder.

Magnesium Carbonate ($MgCO_3$; Molecular Weight, 84).—This occurs native as magnesite; but the official magnesium carbonate, $(MgCO_3)_4.Mg(OH)_2.5H_2O$, is obtained by adding a solution of sodium carbonate,

Na_2CO_3, to a solution of magnesium sulphate, $MgSO_4$, and washing and drying the precipitate produced.

Medicinal Properties and Uses.—Similar to the oxid.

Magnesium Sulphate, *Epsom Salt* ($MgSO_4.7H_2O$; Molecular Weight, 246).—This salt was originally obtained by evaporating the waters of Epsom Springs, England; hence the name. It is made by treating the native carbonate with H_2SO_4.

$$MgCO_3 + H_2SO_4 = MgSO_4 + CO_2 + H_2O$$

Medicinal Properties and Uses.—Cathartic, refrigerant, and diuretic. Dose, from 2 to 8 drams. The *infusion of senna compound*, or "black draught," contains magnesium sulphate, senna, manna, and fennel. The average dose is 4 fluidounces.

Tests of Magnesium.—Solution of magnesium salts, added to NH_4Cl, NH_4OH, and Na_2HPO_4, produces a granular precipitate of $MgNH_4PO_4$.

ALUMINUM

Symbol, Al; Atomic weight, 27; Valence, 3.

This element is very widely distributed in clay and various minerals, principally as silicate. As oxid, it is found in the ruby, sapphire, corundum, and emery.

Properties.—The metal is of a silver-white color, with a slight bluish cast. It is the lightest of the commonly used metals; specific gravity, 2.67; ductile, malleable, hard, and a good conductor of heat and electricity. It is readily dissolved by HCl and alkali hydroxids, produc-

ing H. HNO_3 does not affect it. Aluminum possesses weak basic properties, and its soluble salts are acid in reaction, and liberate CO_2 from carbonates, in the presence of water.

Alums.—The term "alum" is applied to that class of salts composed of the double sulphate of a univalent and trivalent metal with 12 molecules of water of crystallization. *Alums* do not necessarily contain aluminum. The following examples are some of the commoner alums:

Ammonia alum, $NH_4Al(SO_4)_2.12H_2O$.

Chrome alum, $KCr(SO_4)_2.12H_2O$.

Ferric alum, $NH_4Fe(SO_4)_2.12H_2O$.

Potassium alum, $KAl(SO_4)_2.12H_2O$.

The last compound is the official alum, and is the substance that should be given when "alum" is called for. "Ferric alum" is also official, but it will be seen that it does not contain aluminum.

Medicinal Properties and Uses.—Astringent in doses of 5 to 30 gr.; emetic in doses of 1 to 2 drams. Also used externally as a desiccant and astringent.

Alumen exsiccatum, *dried alum, burnt alum,* is alum deprived of its water of crystallization.

Aluminum Hydroxid ($Al(OH)_3$; Molecular Weight, 78).—This is obtained by adding solutions of alkali hydroxids or carbonates to aluminum salts. The gelatinous precipitate obtained is well washed and dried.

Aluminum Sulphate ($Al_2(SO_4)_3$; Molecular Weight, 342).—This is prepared by dissolving aluminum hy-

droxid or oxid in H_2SO_4, and evaporating the solution to dryness.

$$2Al(OH)_3 + 3H_2SO_4 = Al_2(SO_4)_3 + 6H_2O$$

Kaolinum, *Kaolin; Pipe Clay; China Clay.*—This is the native aluminum silicate, used in the preparation of *Cataplasma kaolini*, by incorporating the well-dried kaolin with glycerin and antiseptics. It is used as a poultice, and should be well covered, as it absorbs moisture from the atmosphere, becoming semi-liquid. Kaolin is used as a filtering agent. Combined with petrolatum, it is used in the preparation of pills of those substances which are reduced by organic matter, as silver nitrate and potassium permanganate.

Tests of Aluminum.—Aluminum compounds produce with Na_2CO_3 and NH_4OH a gelatinous white precipitate of $Al(OH)_3$ insoluble in an excess of the reagent. With NaOH or KOH the precipitate is soluble in an excess of the reagent.

IRON

Symbol, Fe; Atomic weight, 55.5; Valence, 2, 3.

Iron is found in nature principally as the oxid and sulphid. It is also found in plants and, in the animal system, in the hematin of the blood. It is the most useful of all the common metals. Specific gravity, 7.78. It forms two classes of compounds: the *ferrous*, light green in color; the *ferric*, usually reddish brown.

Iron by Hydrogen, *Quevenne's Iron; Reduced Iron.*—

This contains about 90 per cent. of metallic iron, and is obtained by passing hydrogen over heated ferric oxid.

$$Fe_2O_3 + 6H = 2Fe + 3H_2O$$

Medicinal Properties and Uses.—A chalybeate tonic in doses of 1 to 5 gr., usually in pills.

Ferric Hydroxid ($Fe(OH)_3$; Molecular Weight, 107).—Made by precipitating a solution of a ferric salt with an alkaline hydroxid or carbonate.

$$FeCl_3 + 3NH_4OH = Fe(OH)_3 + 3NH_4Cl \text{ or}$$

$$Fe_2(SO_4)_3 + 3Na_2CO_3 + 3H_2O = 2Fe(OH)_3 + 3Na_2SO_4 + 3CO_2$$

It is used as an *antidote* to *arsenic-poisoning*, and also as the starting-point of a large number of the official iron compounds and solutions.

Ferrous Chlorid, *Protochlorid of Iron* ($FeCl_2$; Molecular Weight, 182).—Obtained, as a green solution, by treating metallic iron with HCl:

$$Fe + 2HCl = FeCl_2 + 2H$$

The ferrous salts are prone to decomposition and become oxidized to the ferric condition. Such change is prevented by the addition of organic matter, such as sugar.

Ferric Chlorid, *Perchlorid of Iron* ($FeCl_3$; Molecular Weight, 160.5).—This is obtained by oxidizing $FeCl_2$, obtained by the above method, with HNO_3:

$$3FeCl_2 + HNO_3 + 3HCl = 3FeCl_3 + NO + 2H_2O$$

It is found in pharmacy both in the solid state and in solution. The latter contains 29 per cent. of the

anhydrous salt, corresponding to 10 per cent. of metallic iron, and is used in the preparation of *tincture of iron chlorid* by adding to 35 parts of it, by volume, 65 of alcohol.

Ferrous Sulphate, *Green Vitriol; Copperas* ($FeSO_4.7H_2O$; Molecular Weight, 277.5).—Made by dissolving iron in dilute H_2SO_4, evaporating, and crystallizing.

It exists in the form of large transparent, green crystals, soluble in water. When exposed to air, it effloresces, losing water of crystallization, and oxidizes.

Dried sulphate of iron, *exsiccated sulphate of iron* ($FeSO_4$), is the crystallized sulphate of iron deprived of its water of crystallization by heat.

Solution of Ferric Sulphate ($Fe_2(SO_4)_3$; Molecular Weight, 299).—Made by heating $FeSO_4$ with HNO_3 and H_2SO_4:

$$6FeSO_4 + 2HNO_3 + 3H_2SO_4 = 3Fe_2(SO_4)_3 + 2NO + 4H_2O$$

When an excess of the iron sulphate is used the basic or subsulphate of iron (Monsel's solution) is formed. This is used as a styptic.

Ferrous Carbonate ($FeCO_3$; Molecular Weight, 115.5).—This compound is obtained by treating a solution of ferrous sulphate with sodium carbonate:

$$FeSO_4 + Na_2CO_3 = FeCO_3 + Na_2SO_4$$

Ferrous salts have a tendency to undergo oxidation, becoming converted into the ferric condition, which is prevented by the addition of organic matter, as sugar.

Such compounds as *saccharated ferrous carbonate*, *mass of ferrous carbonate* (Vallet's mass), *pills of ferrous carbonate*, and *compound iron mixture* (Griffith's mixture) are official, and are composed of ferrous carbonate with saccharine substances.

Ferric Phosphate ($FePO_4$).—This is a grayish-green powder. The soluble phosphate and pyrophosphate of iron are not true chemical compounds, but mixtures of variable composition.

Ferric Hypophosphite ($Fe(PH_2O_2)_3$; Molecular Weight, 250.5).—This is a grayish-white powder, obtained by adding to a solution of ferric chlorid a solution of sodium hypophosphite, washing, and drying.

Ferrous Iodid (FeI_2; Molecular Weight, 307.5), **Ferrous Bromid** ($FeBr_2$; Molecular Weight, 215.5).—These substances are prepared by the action of iodin and bromin respectively upon metallic iron. They are of light green color; and the former compound is official as *syrup of ferrous iodid*, containing 5 per cent. of FeI_2, and also as *pills of ferrous iodid*, containing 1 gr., coated with balsam of tolu, to prevent oxidation.

Medicinal Properties and Uses.—Tonic, alterative, diuretic, and emmenagogue. Used in anemia, syphilis, skin affections, and amenorrhea. Dose: syrup, 5 to 30 minims; pills, 1 to 2, three times daily.

Scale Salts of Iron.—There are a number of iron salts, official, existing in the form of thin transparent scales, as the citrate, citrate of iron and ammonium,

iron and potassium tartrate, iron and ammonium tartrate, phosphate, and the pyrophosphate. These are made by dissolving ferric hydroxid (*q. v.*) in the respective acids or acid salts, as in the case of the double iron compounds.

Tests of Iron.—*Ferrous salts*, with the soluble hydroxids and carbonates, produce light green precipitates; with potassium ferricyanid, a blue precipitate.

Ferric salts, with soluble hydroxids and carbonates, produce reddish-brown precipitates and an effervescence with the latter class. With acetates and potassium sulphocyanid blood-red solutions are obtained. With potassium ferrocyanid a precipitate of Prussian blue is obtained. Tannin produces black precipitates, and for this reason iron should not be dispensed with astringent vegetable substances.

MANGANESE

Symbol, Mn; Atomic weight, 55.

It is found principally as the dioxid. It forms three classes of salts: the manganous, which are pink and bivalent; the manganic, which are green and tetravalent; and the permanganates, which are purple and play the part of an acid.

Precipitated Manganese Dioxid (MnO_2; Molecular Weight, 87).—The native MnO_2 is too impure for medicinal use, and the compound, which is official, is made by adding to NH_4OH a solution of manganous

sulphate, $MnSO_4$ and H_2O_2, and thoroughly washing the precipitate.

Medicinal Properties.—Tonic and alterative. Dose, 3 to 10 gr.

Manganese Sulphate ($MnSO_4$; Molecular Weight, 151).—Prepared by the action of H_2SO_4 upon the native MnO_2.

$$MnO_2 + H_2SO_4 = MnSO_4 + H_2O + O$$

Medicinal Properties.—Tonic, cholagogue, cathartic, and styptic. Dose, 3 to 10 gr.

Manganese Hypophosphite ($Mn(PH_2O_2)_2.H_2O$; Molecular Weight, 203).—Made by adding to a solution of manganese sulphate a solution of calcium hypophosphite, and separating the solution from the precipitated $CaSO_4$, evaporating, and allowing to crystallize. This salt, which is of a pink color, is used in the preparation of the *compound syrup of the hypophosphites.*

Potassium Permanganate ($KMnO_4$; Molecular Weight, 158).—Made by fusing MnO_2 with $KClO_3$ and K_2CO_3. The green mass, which is potassium manganate, is dissolved in water, filtered, and to the filtrate H_2SO_4 is added. MnO_2 is precipitated, and the purplish-red solution of $KMnO_4$ is decanted, evaporated, and crystallized.

Properties.—This is a powerful oxidizing agent, disinfectant, and antiseptic. It must not be mixed with organic matter, as it is reduced by the latter, in the

absence of acids, to a lower form, which is insoluble; in the presence of acids, to soluble salts of manganese.

Medicinal Properties and Uses.—Disinfectant, deodorant, antiseptic, and emmenagogue. Dose, 2 to 5 gr., best given in pills or tablets.

Tests.—Manganese compounds produce with ammonium sulphid, $(NH_4)_2S$, a flesh-colored precipitate of MnS. Fused with potassium nitrate and carbonate, a green mass is produced.

CHROMIUM

Symbol, Cr; Atomic weight, 52; Valence, 2, 4, 6.

The name chromium is given to this metal from *chromus*, color, owing to the fact that the compounds of it are highly colored. It is found as chrome iron. It forms three classes of compounds: two in which they are basic, and one in which the acidic property predominates.

Chromium Trioxid (CrO_3; Molecular Weight, 100).—This compound was formerly called chromic acid. It is the anhydrid of true chromic acid, H_2CRO_4. (See foot-note, page 39.) It exists in the form of purplish-red crystals, very soluble in water, with which it forms chromic acid. It is one of the most powerful oxidizing agents. *Under no circumstances should it be mixed with organic matter.* In contact with alcohol, ether, or glycerin violent reaction occurs, from the liberation of oxygen, even setting fire to it.

Uses.—Externally as escharotic, astringent, and disinfectant. Never use with cotton tampon or camel's-hair pencil, but with a glass brush, protecting the healthy part by a dam of petrolatum.

Potassium Dichromate ($K_2Cr_2O_7$; Molecular Weight, 294).—This is found in commerce in the form of orange-red crystals. It is poisonous, irritant, and caustic. It is seldom given internally, but when used as an alterative is given in doses of $\frac{1}{5}$ gr. Poisoning is marked by violent irritation and corrosive condition. Give alkaline carbonates, emetics, demulcent drinks, and albumin.

Chromium Sulphate ($Cr_2(SO_4)_3$; Molecular Weight, 292).—This occurs in emerald-green scales, soluble in water, and has recently come into use as a remedial agent.

Tests of Chromium.—As chromates or dichromates: Add to the solution of the suspected substance a few drops of H_2SO_4 and H_2O_2, followed by a layer of ether. Shake; the ethereal layer will turn blue, due to the formation of *perchromic acid.*

With soluble lead salts, a yellow precipitate of lead chromate is formed, $PbCrO_4$.

Basic chromium compounds: With NH_4OH, a green precipitate of chromium hydroxid is produced, $Cr(OH)_3$.

NICKEL

Symbol, Ni; Atomic weight, 58.

COBALT

Symbol, Co; Atomic weight, 58.

The salts of these metals are of some chemical and industrial importance, but practically do not enter to any extent into the domain of medicine. Nickel, in the metallic state, is principally used as a protective for other metals. The salts of nickel are green, while those of cobalt are pink.

ZINC

Symbol, Zn; Atomic weight, 65; Valence, 2.

Metallic zinc is a bluish-white metal, soluble in dilute acids and alkalis, liberating hydrogen in both instances. It is found as the sulphid and carbonate, and also, in combination, as the silicate.

Zinc Oxid, *Zinc White* (ZnO; Molecular Weight, 81).—This is a tasteless white powder, insoluble in water, but freely in acids, with which it produces salts. Obtained by calcination of the carbonate:

$$ZnCO_3 = ZnO + CO_2$$

Uses.—Astringent, desiccant, and antispasmodic in doses of 1 to 5 gr.

The *ointment of zinc oxid* is official, containing 20 per cent. of it.

Zinc Sulphate, *White Vitriol* ($ZnSO_4.7H_2O$; Molecular Weight, 287).—Made by dissolving metallic zinc or the oxid in H_2SO_4:

$$ZnO + H_2SO_4 = ZnSO_4 + H_2O.$$

This occurs in small white crystals, resembling Epsom salts, for which it is sometimes mistaken. It is very soluble in water.

Medicinal Properties and Uses.—Tonic and astringent in doses of 1 to 3 gr. As an emetic, 10 to 30 gr.

Zinc Chlorid ($ZnCl_2$; Molecular Weight, 135).—This is a highly deliquescent salt made by the action of HCl upon metallic zinc.

$$Zn + 2HCl + ZnCl_2 + 2H$$

Uses.—It is astringent and escharotic and largely used as an embalming fluid. It has been for a long time highly recommended as a disinfectant, but recent researches have failed to make such claim good.

Zinc Carbonate, *Precipitated Carbonate of Zinc* ($ZnCO_3$; Molecular Weight, 125).—Made by adding to a solution of zinc sulphate a solution of sodium carbonate:

$$ZnSO_4 + Na_2CO_3 = ZnCO_3 + Na_2SO_4$$

It possesses properties similar to the oxid.

Zinc Bromid ($ZnBr_2$, Molecular Weight, 225), **Zinc Iodid** (ZnI_2; Molecular Weight, 317).—These salts are made by adding their respective acids to zinc oxid or carbonate. Their medicinal properties are very similar to those of the iodids and bromids of the other metals.

Zinc Acetate ($Zn(C_2H_3O_2)_2.2H_2O$; Molecular Weight, 219).—Made by dissolving zinc oxid in acetic acid, evaporating, and crystallizing.

Medicinal Properties.—Astringent, irritant, and emetic. Dose, 1 to 3 gr.

Zinc Valerate.—This compound, possessing the odor of valeric acid, is an antispasmodic and nervine, best administered in pills or cachets in doses of 1 to 3 gr.

Zinc Phenolsulphonate ($Zn(C_6H_5O_4S)_2.8H_2O$; Molecular Weight, 555).—This is an antiseptic, used as a substitute for phenol; soluble in water and alcohol.

Tests of Zinc.—Solutions of zinc will give white precipitates with H_2S, $(NH_4)_2S$, and $(NH_4)_2CO_3$.

With NH_4OH, gelatinous precipitate, soluble in an excess of the reagent.

LEAD

Symbol, Pb; Atomic weight, 206; Valence, 2.

The principal ore of lead is galena, PbS, but lead is also found as the carbonate. It is a very soft metal and can be cut with a knife. It is soluble in HNO_3 and acetic acids. Other acids have but little effect upon lead. It is used for water-pipes, which, through the action of the contained oxygen of the water, become coated with oxid, and this, by further action of water, is converted into the hydroxid, which is slightly soluble. Another source of such contamination is due to CO_2, nitrites, and nitrates that may be contained in the water. Workers in lead or paint factories are frequently affected by it. Great care should be exercised in handling lead compounds, and the inhalation of them should be avoided.

Factory commissions of several States have taken up this matter, and have shown how the lives of the employees can be protected by proper care.

Toxicology.—Chronic poisoning by lead is characterized by indigestion, colic, and constipation, with partial paralysis of the extensor muscles of the forearm, palsy and wrist-drop, and by a blue line, from deposition of lead sulphid, PbS, on the gums. The treatment consists of clearing out the alimentary canal with magnesium sulphate, which acts both as a cathartic and an antidote, forming the insoluble lead sulphate, $PbSO_4$. Potassium chlorate or iodid should also be given to eliminate the lead from the system. Acute lead-poisoning is similar to the above, but more pronounced in its activity.

Lead Oxid, *Litharge* (PbO; Molecular Weight, 222).—Usually obtained, as a by-product, by heating lead with air. It is a yellowish, amorphous powder, used in the manufacture of the lead salts, for making the glaze on pottery ware, and as a dryer in paints. When boiled with a solution of lead acetate it forms the *solution of lead subacetate*, or *Goulard's extract*, a diluted solution of which is known as "lead-water."

Red lead (Pb_3O_4) is a red powder used in paints, and has been shown to be composed of PbO and PbO_2.

Lead Carbonate, *White Lead; Flake White* ($2PbCO_3 \cdot Pb(OH)_2$; Molecular Weight, 772).—The native carbonate of lead has the formula $PbCO_3$, but from the

formula of the above compound it will be seen that it is a mixture of both the carbonate and hydroxid. Its principal use is as a pigment and as a basis for other paints. It was once official, used as a dusting-powder and as an ointment.

Lead Nitrate ($Pb(NO_3)_2$; Molecular Weight, 330).—Made by dissolving either metallic lead or the oxid in HNO_3:

$$PbO + 2HNO_3 = Pb(NO_3)_2 + H_2O$$

Its principal use, chemically, is in the manufacture of the other lead compounds.

Medicinal Properties and Uses.—Astringent, discutient, and deodorizer.

Lead Acetate, *Sugar of Lead* ($Pb(C_2H_3O_2)_2.3H_2O$; Molecular Weight, 378).—Made by dissolving PbO in dilute acetic acid, evaporating, and crystallizing. It occurs in large colorless crystals, soluble in water. It has a styptic and sweet taste; whence its name, "sugar of lead."

Medicinal Properties and Uses.—Internally, astringent and sedative, in doses of 1 to 4 gr., usually combined with opium. Externally, astringent in contusions and sprains. It is used in the preparation of the *solution of lead subacetate;* and also for making *lead plaster*, by adding to a solution of it a solution of Castile soap, thoroughly washing with hot water the mass obtained, and forcing out any retained water by kneading. From the lead plaster the *diachylon ointment* is made, and the

plaster is used as the basis of most of the other official plasters.

Lead Iodid (PbI_2; Molecular Weight, 458).—This is a heavy, yellow, insoluble powder, prepared by adding to a solution of lead nitrate a solution of potassium iodid, washing, and drying.

$$Pb(NO_3)_2 + 2KI = PbI_2 + 2KNO_3$$

Medicinal Properties.—Resolvent, given in doses of 1 to 4 gr., in pills, and also used externally as an ointment.

Tests of Lead.—H_2S and $(NH_4)_2S$ produce a black precipitate of PbS.

Solution of KI produces a yellow precipitate of PbI_2.

Solution of potassium dichromate, $K_2Cr_2O_7$, produces a yellow precipitate of lead chromate, $PbCrO_4$.

COPPER

Symbol, Cu; Atomic weight, 63; Valence, 2.

Copper is the only metal of a red color. It is slowly oxidized by air at ordinary temperature, but when heated forms the black oxid. In moist air it becomes coated with a layer of the subcarbonate. It is acted upon by HNO_3, but the other acids, in the cold, have practically no effect upon it. It is a good conductor of heat and electricity. It is found in the metallic state and also in combination with sulphur. It forms alloys with a number of the metals, the most common of which are brass (composed of copper and zinc); another alloy is

bronze (copper, zinc, and tin). It forms two classes of compounds, the cuprous and cupric.

Cuprous Oxid, *Red or Suboxid of Copper* (Cu_2O; Molecular Weight, 142).—It is formed when cupric oxid is heated with carbon or organic matter; or when an alkaline solution of copper is heated in the presence of some organic matter, notably grape-sugar or glucose. In testing urine for glucose, using Fehling's solution, the red precipitate produced is cuprous oxid. In the arts, cuprous oxid is used in making red glass.

Copper Nitrate ($Cu(NO_3)_2$; Molecular Weight, 187).—This is a green crystalline salt, obtained by the action of HNO_3 upon Cu.

$$3Cu + 8HNO_3 = 3Cu(NO_3)_2 = 2NO + 4H_2O$$

Copper Sulphate, *Blue Stone; Blue Vitriol* ($CuSO_4 \cdot 5H_2O$; Molecular Weight, 249).—Copper sulphate is the only official copper salt. It occurs in large, transparent, deep-blue crystals, readily soluble in water. It is formed by the action of concentrated, hot H_2SO_4 upon copper.

Medicinal Properties.—Astringent, tonic, irritant, escharotic, and emetic, and is used as an antidote to phosphorus-poisoning. Dose, $\frac{1}{8}$ to $\frac{1}{2}$ gr.; for phosphorus-poisoning, from 2 to 10 gr.

Copper Carbonate.—This is the double carbonate and hydroxid of copper, occurring as a heavy, light-green powder, made by the interaction between sodium car-

bonate and copper sulphate, and is principally used as a paint.

Copper-poisoning.—Contrary to the popular belief, copper is not poisonous in small doses, although in large amounts it is. It produces vomiting, purging, colic, tenesmus, and suppression of urine.

Treatment.—Use stomach-pump and give albumin, either as the white of eggs or milk. Reduced iron may be given or even a *very dilute solution* of potassium ferrocyanid, $K_4Fe(CN)_6$, followed by emetics or stomach-pump.

Tests of Copper.—NH_4OH produces with copper solutions a bluish-white precipitate of $Cu(OH)_2$, soluble in an excess of the reagent to a deep azure-blue solution, due to the formation of a cupro-ammonium compound (very characteristic).

Potassium ferrocyanid produces, even in very dilute solutions of copper, a reddish-brown precipitate of copper ferrocyanid.

Metallic iron, thoroughly cleaned of grease, when dipped into acid solutions of copper, becomes coated with a metallic deposit of copper.

BISMUTH

Symbol, Bi; Atomic weight, 207.

Bismuth is a silver-gray metal with a pinkish cast, quite brittle, and possesses a crystalline structure. Its most characteristic property is its formation, with some

of the metals, of alloys that fuse at exceedingly low temperatures; some as low as 60.5° C. (140° F.). The metal also differs from the general rule of expansion and contraction by expanding in volume upon cooling. Solutions of bismuth salts are also characterized, when not too acid, by precipitating as insoluble basic salts when thrown into an excess of water.

Bismuth Subnitrate (Approximate Formula, $Bi(OH)_2NO_3$).—When metallic bismuth is acted upon by HNO_3, the normal nitrate is produced:

$$Bi + 4HNO_3 = Bi(NO_3)_3 + NO + 2H_2O$$

When this solution is poured into a large quantity of water, bismuth subnitrate is precipitated, which is of variable composition.

$$Bi(NO_3)_3 + 2H_2O = Bi(OH)_2NO_3 + 2HNO_3$$

Properties.—This is a heavy, white, tasteless powder, which imparts an acid reaction to water, due to its readiness in giving up its nitric acid radicle. Hence, bismuth subnitrate, dispensed with carbonates or bicarbonates in aqueous mixtures, liberates CO_2, and care must be taken to see that the reaction is complete before corking the container, or an explosion may occur.

Bismuth Subcarbonate, *Pearl White* ($(BiO)_2CO_3$; Molecular Weight, 506).—If a solution of the normal nitrate is added to a solution of sodium carbonate, the subcarbonate is precipitated:

$$2Bi(NO_3)_3 + 3Na_2CO_3 = (BiO)_2CO_3 + 6NaNO_3 + 2CO_2$$

This enters largely into the manufacture of the various cosmetics and face preparations with which the market is flooded.

Medicinal Properties and Uses.—Both the subnitrate and subcarbonate are similar in medicinal behavior. They are sedatives, astringents, and act mechanically by coating the mucosa with a protective film. Dose, 5 to 30 gr.

The latter is also used extensively in *x*-ray work, as it retards, to some extent, the passage of the rays, and permits the radiologist to gain a proper conception of the conditions of the alimentary tract.

Bismuth Citrate ($Bi(C_6H_5O_7)$; Molecular Weight, 396).—Made by boiling a solution of nitric acid with bismuth subnitrate until a part of the precipitate is wholly soluble in NH_4OH, with which it forms the double *bismuth and ammonium citrate*, which is the only soluble bismuth salt, and which enters into the preparation of *elixir of bismuth.*

Bismuth Subsalicylate (Approximate Formula, $Bi(OH)_2C_7H_5O_3$).—Made by digesting salicylic acid, $HC_7H_5O_3$, with bismuth hydroxid, $Bi(OH)_3$.

Medicinal Properties and Uses.—It is an internal antiseptic and astringent, passing through the stomach unchanged, but being decomposed in the intestinal tract. Dose, 5 to 15 gr.

Bismuth Subgallate, *Dermatol* (Approximate Formula, $Bi(OH)_2C_7H_5O_5$).—Made by digesting bismuth sub-

nitrate in a solution of gallic acid. It occurs as a canary-yellow powder, odorless, tasteless, and insoluble in water or alcohol. It is decomposed by acids, liberating gallic acid.

Medicinal Properties.—Antiseptic, sedative, astringent, and desiccant. Dose, 5 to 30 gr.

Tests of Bismuth.—Solutions of bismuth produce white precipitates of bismuth hydroxid, $Bi(OH)_3$, with the hydroxids of ammonium, sodium, and potassium. With solutions of KI, a brown precipitate of bismuth iodid, BiI_3, soluble in an excess of KI.

SILVER

Symbol, Ag; Atomic weight, 107.

While silver is occasionally found in the native condition, it more frequently occurs as the sulphid, usually associated with lead. It is a brilliant white metal, very ductile and tenacious. When exposed to air containing sulphids it becomes covered with a thin film of silver sulphid. It is insoluble in HCl. H_2SO_4 and HNO_3 dissolve it. Caustic alkalis have no effect upon it.

Silver Nitrate ($AgNO_3$; Molecular Weight, 169).—This is prepared by dissolving metallic silver in HNO_3, evaporating, and crystallizing:

$$3Ag + 4HNO_3 = 3AgNO_3 + NO + 2H_2O.$$

Silver nitrate is exceedingly soluble in water; solutions containing as high as 75 per cent. of the salt can be prepared. When exposed to light in the presence of organic matter, it decomposes into metallic silver and

HNO_3. When placed upon tissues, it first turns them white, due to the silver chlorid formed by the interaction of the $AgNO_3$ and the NaCl contained in the tissues, and finally black, from further reduction to metallic silver and the oxid. Stains may be removed, if not left too long after the application of the salt, by applying iodin, forming silver iodid, AgI, and then washing with a solution of sodium thiosulphate, $Na_2S_2O_3$.

Medicinal Properties and Uses.—Alterative, stimulant, and astringent; given in doses of $\frac{1}{8}$ to $\frac{1}{2}$ gr., in pills made with cocoa-butter or kaolin (*q. v.*). Externally it is a superficial escharotic.

Silver nitrate is also used in indelible ink, for hair-dyes, and for photographic purposes.

Lunar Caustic.—If to $AgNO_3$ some HCl is added and then fused, a hard mass is obtained, which is molded into sticks, which are not as brittle as $AgNO_3$.

Silver Oxid (Ag_2O; Molecular Weight, 230).—Prepared by addition of the alkali hydroxids to $AgNO_3$. This is soluble in an excess of NH_4OH, forming a compound which possesses explosive properties.

Silver Cyanid (AgCN; Molecular Weight, 133).—Made by passing HCN into a solution of $AgNO_3$.

This compound is used for the extemporaneous preparation of HCN, by treating it with the required quantity of HCl and water, and separating the acid from the insoluble AgCl:

$$AgCN + HCl = HCN + AgCl$$

Silver Iodid (AgI; Molecular Weight, 233).—Made by double decomposition between $AgNO_3$ and KI. It is used in photography.

Toxicology.—Silver salts are poisonous. The antidote is NaCl, forming the insoluble AgCl, followed by emetics.

Tests of Silver.—HCl and soluble chlorids produce, with silver salts, a white precipitate of AgCl, soluble in NH_4OH, and reprecipitated by HNO_3. $K_2Cr_2O_7$ gives a reddish precipitate, with silver salts, of Ag_2CrO_4.

MERCURY

Symbol, Hg; Atomic weight, 199; Valence, 1, 2.

Mercury differs from all other metals by being liquid at ordinary temperature. It is found principally as cinnabar, HgS. It is of silvery white appearance. Its specific gravity is 13.59, becoming solid at —40° C. or F. When pure, it remains unaltered in air, and rolls without leaving streaks. It forms *amalgams* with most metals (none with iron), and is not affected by HCl or cold H_2SO_4. HNO_3 attacks it vigorously. It forms two classes of compounds, mercurous and mercuric; the former milder in action, and the latter poisonous. There are several medicinal preparations in which mercury exists practically in the metallic condition: *Mercury with chalk*, *Hydrargyrum cum creta*, gray powder, containing 38 per cent.; *Massa hydrargyrum*, *blue mass*, blue pill, containing 33 per cent.; *Unguentum hydrargy-*

rum; Unguentum hydrargyrum dilutum, blue ointment, 33 per cent.; and *Emplastrum hydrargyrum, mercury plaster,* 30 per cent.

Mercurous Oxid, *Black Oxid of Mercury* (Hg_2O; Molecular Weight, 414).—When a mercurous compound is acted upon by an alkali, except ammonia, mercurous oxid is obtained. In the preparation known as "Lotio nigra," or *black wash,* mercurous oxid is contained:

$$2HgCl + Ca(OH)_2 = CaCl_2 + Hg_2O + H_2O$$

Mercuric Oxid (HgO; Molecular Weight, 215).—In the U. S. P. two mercuric oxids are official; they are of the same chemical composition, but differ in their physical properties. The yellow mercuric oxid is made by adding to a solution of NaOH a solution of mercuric chlorid, $HgCl_2$, washing, and drying the precipitate produced:

$$HgCl_2 + 2NaOH = HgO + 2NaCl + H_2O$$

Red mercuric oxid, red precipitate, is formed when mercuric nitrate is heated:

$$Hg(NO_3)_2 = HgO + 2NO + O_3$$

Mercurous Chlorid, *Mild Chlorid of Mercury; Calomel* (HgCl; Molecular Weight, 234).—The chlorids of mercury are made by the process of *sublimation,* which consists of vaporizing a solid and passing the vapor into a cooled chamber, where it is condensed to a powdery condition.

A mixture of mercurous sulphate and sodium chlorid

are sublimed, the mercurous chlorid formed, being volatile, passes over, leaving sodium sulphate in the retort:

$$Hg_2SO_4 + 2NaCl = 2HgCl = Na_2SO_4$$

As there is a possibility of the calomel being contaminated with mercuric chlorid, it is washed with water, to remove any mercuric chlorid it may contain. It must be preserved in bottles protected from light, as it is decomposed by the latter, forming mercury and mercuric chlorid.

Medicinal Properties and Uses.—Anthelmintic, alterative, and cholagogue. Dose, 1 to 15 gr. It is an ingredient of *compound cathartic pills*, each pill containing 1 gr. of it.

Mercuric Chlorid, *Corrosive Sublimate; Corrosive Chlorid of Mercury* ($HgCl_2$; Molecular Weight, 269).—This is made by a process similar to making calomel, substituting mercuric sulphate for the mercurous sulphate:

$$HgSO_4 + 2NaCl = HgCl_2 + Na_2SO_4$$

It is a heavy, crystalline solid, soluble in 16 parts of water, the solubility being greatly increased by addition of ammonium chlorid. The antiseptic tablets of pharmacy contain 7.3 gr. of mercuric chlorid and 7.7 gr. of ammonium chlorid. One tablet dissolved in a pint of water forms a solution of 1 : 1000. Mercuric chlorid is soluble in 3 parts of alcohol and in 4 parts of ether.

Medicinal Properties and Uses.—Poisonous, highly corrosive, antiseptic, alterative, diuretic, and tonic.

Used in syphilis, skin affections, and rheumatism. Dose, $\frac{1}{60}$ to $\frac{1}{8}$ gr.

Toxicology.—Poisoning is best treated with albumin (one egg to each 4 gr.), followed by emetics and demulcent drinks. In the absence of albumin, solutions of sodium sulphate or magnesium sulphate may be given.

Mercurous Iodid, *Yellow Iodid of Mercury; Protoiodid of Mercury* (HgI; Molecular Weight, 325).—Made by the interaction of mercurous nitrate and potassium iodid:

$$Hg(NO_3) + KI = HgI + KNO_3$$

It is a bright yellow, amorphous powder. It was formerly called green iodid of mercury, on account of its color; being made by rubbing mercury and iodin together, in the presence of alcohol, the small amount of uncombined mercury imparting a green color to the compound. Its medicinal properties resemble those of other mercuric compounds, and its dose is $\frac{1}{6}$ to 1 gr.

Mercuric Iodid, *Red Iodid of Mercury; Biniodid of Mercury* (HgI_2; Molecular Weight, 451).—Made by mixing solutions of mercuric chlorid and potassium iodid in exact molecular proportions, as mercuric iodid is soluble in an excess of either solution.

$$HgCl_2 + 2KI = HgI_2 + 2KCl$$

Dose, $\frac{1}{60}$ to $\frac{1}{8}$ gr.

Mercury Nitrates.—Two nitrates of mercury exist. They are made by the action of nitric acid upon mercury. If cold dilute nitric acid is used with an excess

of mercury, mercurous nitrate is formed. With an excess of strong HNO_3, mercuric nitrate results:

$$3Hg + 8HNO_3 = 3Hg(NO_3)_2 + 2NO + 4H_2O$$

Solution of mercuric nitrate is official, contains 60 per cent. by weight of $Hg(NO_3)_2$, and is used as an escharotic. *Ointment of mercuric nitrate, citrine ointment*, contains about 11.5 per cent. of $Hg(NO_3)_2$.

Mercury Subsulphate, *Turpeth Mineral* ($HgSO_4 \cdot (HgO)_2$; Molecular Weight, 725).—This was formerly extensively used as an emetic for children, in doses of 2 to 3 gr. It is made by pouring a solution of mercury bisulphate into water and washing free of the acid.

Ammoniated Mercury, *White Precipitate* (NH_2HgCl; Molecular Weight, 250).—This is a white, pulverulent substance, insoluble in water, used only externally. The ointment, containing 10 per cent., is official. Ammoniated mercury is made by adding $HgCl_2$ to NH_4OH:

$$HgCl_2 + 2NH_4OH = NH_2HgCl_2 + NH_4Cl + 2H_2O$$

Tests of Mercury.—

	Mercuric compounds.	Mercurous compounds.
Potassium iodid produces	A red precipitate, HgI_2.	A yellow precipitate, HgI.
Sodium or potassium hydroxid produces	A yellow precipitate, HgO.	A black precipitate, Hg_2O.
HCl produces	No effect.	A white precipitate, HgCl.
NH_4OH produces	A white precipitate, NH_2HgCl.	A black precipitate of mercurous ammoniated mercury.

ARSENIC

Symbol, As; Atomic weight, 75; Molecular weight, 300.

Although arsenic is found in small quantities in the native state, its principal source is the sulphid. It exists in steel-gray, crystalline form, with a metallic luster, without odor or taste, insoluble in water. By HNO_3 it is converted into arsenic acid, H_3AsO_4.

Arseniuretted Hydrogen, *Arsine* (AsH_3; Molecular Weight, 78).—This is a highly poisonous, colorless gas, which burns with a bluish flame, producing As_2O_3 and H_2O. It is always formed when *nascent* hydrogen comes in contact with arsenic or its compounds:

$$12H + As_2O_3 = 2AsH_3 + 3H_2O$$

Arsenic Trioxid, *Arsenous Oxid; White Arsenic* (As_2O_3; Molecular Weight, 198).—This substance is usually produced, as a by-product, during the manufacture of the metal from its ores. It occurs in two varieties: the opaque, or crystalline, and the vitreous, or amorphous. Very slightly soluble in water, its solubility is increased by HCl. *Liquor acidi arsenosi*, solution of arsenous acid, contains 1 per cent. of As_2O_3 in HCl and water. (All liquid preparations of arsenic contain 1 per cent. of the arsenical compound.)

Solution of Potassium Arsenite, Fowler's Solution.—Made by boiling As_2O_3 with potassium bicarbonate, $KHCO_3$, and flavoring and coloring with compound spirits of lavender.

Sodium Arsenate ($Na_2HAsO_4.7H_2O$; Molecular Weight 312).—Made by fusing As_2O_3 with Na_2CO_3 and $NaNO_3$. A one per cent. solution of the anhydrous salt is official.

Arsenic Iodid (AsI_3; Molecular Weight, 453).—This substance, when combined with mercuric iodid and water, forms *Liquor arsenii et hydrargyri iodidi, Donovan's solution*, containing 1 per cent. each of the salts.

Arsenic-poisoning.—Poisoning by arsenic may result from a number of causes. Wall-paper often contains arsenic, which falls off and is inhaled. Textile substances also contain it, and poisoning may arise by direct absorption or by reduction of the arsenical compounds contained in them. Arsenic is an irritant, and symptoms of arsenic-poisoning resemble those of cholera: constriction and heat of the fauces, faintness, nausea, burning abdominal pains, thirst, vomiting, bloody stools, and suppression of urine.

Toxicology.—The stomach should be washed out, emetics, followed by freshly precipitated ferric hydroxid (*q. v.*) or dialysed iron, which forms the insoluble iron arsenite, followed by emetics.

Tests of Arsenic.—H_2S produces, in acidified solutions of arsenic, a yellow precipitate of arsenic sulphid, As_2S_3, soluble in $(NH_4)_2S$.

Marsh's Test.—Hydrogen is generated in a flask by the action of H_2SO_4 upon zinc. After having ascertained the absence of air in the flask, the hydrogen is ignited, and the purity of the chemicals used is tested.

The suspected liquid is then added. In the presence of arsenic the flame becomes enlarged, and when a cold porcelain surface impinges upon the flame, it will deposit upon the porcelain metallic spots. As spots produced by antimony are quite similar in appearance, they are differentiated by a solution of chlorinated soda or Labarraque's solution, which dissolves the arsenic spots, but not those of antimony. The arsenic spots are further confirmed by acidifying the solution in which the arsenic is dissolved, and passing H_2S into it, a yellow precipitate being formed if arsenic is present.

NH_4OH, to which copper sulphate has been added until the precipitate first produced no longer dissolves, and filtered, produces, with arsenic, a precipitate of Scheele's green.

A solution of ammonio-nitrate of silver gives a yellow precipitate with arsenic.

ANTIMONY

Symbol, Sb; Atomic weight, 119.

Antimony is found as black antimony sulphid, Sb_2S_3. It is a bluish-white metal of a crystalline structure, soluble in HCl. It is used in the arts as type and Babbitt metal.

Antimony Sulphid (Sb_2S_3; Molecular Weight, 334).—This occurs native, and is used in the preparation of "horse powders." Under the name of sulphureted antimony, or kermes-mineral, a substance is known

which is an orange-red powder and consists of a mixture of sulphid and oxid of antimony. This is a diaphoretic and is given in doses of 1 to 2 gr.

Antimony Chlorid, *Butter of Antimony* ($SbCl_3$; Molecular Weight, 224).—This is an escharotic, obtained by boiling Sb_2S_3 with HCl.

Antimony Oxid (Sb_2O_3; Molecular Weight, 286).—A white, insoluble powder, entering into the preparation of *Pulvis antimonialis*, or James' powder. It is made by pouring a solution of $SbCl_3$ into water, and heating the oxychlorid formed with Na_2CO_3.

Antimony and Potassium Tartrate, *Tartar Emetic* ($2K(SbO)C_4H_4O_6.H_2O$); Molecular Weight, 662).—This is the most important medicinal antimony compound. It is prepared by boiling potassium bitartrate, or cream of tartar, with freshly prepared antimony oxid:

$$Sb_2O_3 + 2KHC_4H_4O_6 = 2K(SbO)C_4H_4O_6 + H_2O$$

It exists in small crystals, soluble in 16 parts of water and insoluble in alcohol. *Wine antimony* contains about 2 gr. to the fluidounce. *Compound syrup of squills*, or *hive syrup*, contains about 1 gr. to the fluidounce.

Medicinal Properties and Uses.—Sedative, alterative, expectorant, and emetic. Dose, $\frac{1}{32}$ to $\frac{1}{2}$ gr., depending upon the purpose intended.

Toxicology.—Tartar emetic is extensively used in the numerous "ant destroyers," which are frequent sources of poisoning. In its effects it is similar to arsenic, but

of a milder type. As little as 2 gr. have produced death. Treatment similar to arsenic, but with the addition of tannic acid or substances containing it, as tea, etc.

Tests of Antimony.—H_2S produces, with acidified antimony solution, an orange-colored precipitate of the sulphid, Sb_2S_3, soluble in $(NH_4)_2S$.

Under Arsenic, Marsh's Test was given, with points of distinction between arsenic and antimony.

PART II

CHEMISTRY OF CARBON AND ITS COMPOUNDS

THE term "Organic Chemistry," by which these compounds are commonly alluded to, is a survival from the former belief that these substances were produced by the mysterious power, "vital force," which is now demonstrated by the large number of these substances daily produced in chemical laboratories to have no bearing upon it. The number of carbon compounds is very large. It is estimated that there are 150,000 of them known at the present time, and their number is rapidly increasing as our knowledge of the subject progresses. The elements entering into them are principally carbon and hydrogen, although oxygen is also an important component. In addition to the foregoing, there is also nitrogen, and other compounds may contain sulphur, phosphorus, chlorin, iodin, bromin, and even the metals are combined with some of them.

The carbon compounds are derived from all sources. From the animal kingdom there is obtained the proteins, urea, fats, etc.; the vegetable kingdom furnishes

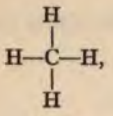
sugars, starches, alkaloids, glucosids, etc.; the mineral kingdom supplies petroleum, hydrocarbon, gases, and coal-tar.

Identification of Carbon Compounds.—The non-volatile substances are readily recognized by the fact that when highly heated they char, due to the destruction of the compound, leaving carbon as a blackened mass. In some instances the addition of sulphuric acid is ample to show their presence; the dehydrating property of the acid removes hydrogen and oxygen, and the blackened carbon remains. In most cases it becomes necessary to heat the substance with copper oxid, which furnishes oxygen, producing CO_2, which, when passed into $Ca(OH)_2$, becomes cloudy.

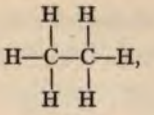
For convenience of study the carbon compounds are divided into groups which have characteristics in common.

Hydrocarbons.—As the name implies, these are composed of carbon and hydrogen *only*. They are divided into three main classes or groups: The "aliphatic," or "open chain"; the "aromatic," or "closed chain"; the "terpenes." Each of these groups are further subdivided.

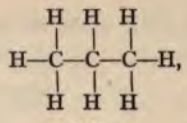
Hydrocarbons are graphically shown to exist in chains, which are series of multivalent atoms held together by one or more affinities. The linkage may be shown as existing with one valence between each carbon, as in "saturated hydrocarbons" or "paraffins":



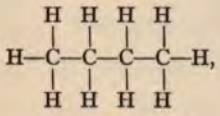
CH_4
Methane.



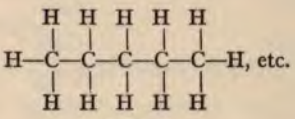
C_2H_6
Ethane.



C_3H_8
Propane.

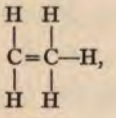


C_4H_{10}
Butane.

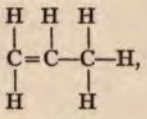


C_5H_{12}
Pentane.

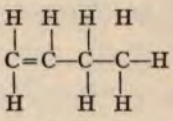
or with double linking, as in the ethylene hydrocarbons, or "olefins":



C_2H_4
Ethene or ethylene.

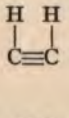


C_3H_6
Propene or propylene.

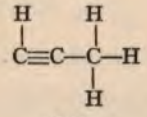


C_4H_8
Butene or butylene.

It will be noticed that each carbon in the above examples has four valencies, and that in the "ethylene" series one of the carbons is linked to the other by two bonds, while in the "paraffin" series each carbon is linked to the other by a single bond. In the acetylene hydrocarbons the linkage is triple:



C_2H_2
Acetylene.



C_3H_4
Allylene.

HYDROCARBONS OF THE MARSH-GAS OR PARAFFIN SERIES
(the Saturated Hydrocarbons)

General Formula, C_nH_{2n+2}.

Name.	Formula.	Radicle.	Formula.
Methane	CH_4	Methyl	(CH_3)
Ethane	C_2H_6	Ethyl	(C_2H_5)
Propane	C_3H_8	Propyl	(C_3H_7)
Butane	C_4H_{10}	Buty	(C_4H_9)
Pentane	C_5H_{12}	Pentyl	(C_5H_{11})
Hexane	C_6H_{14}	Hexyl	(C_6H_{13})

This series could be continued almost indefinitely, as compounds containing as many as 60 carbons are known. It will be observed that there is a common difference of CH_2 between any member of this series and the preceding or succeeding one. The term *homologous* is given to a series possessing this difference, and each member of the series is regarded as the *homologue* of the others.

It will also be observed that the formula of any member of the series can be readily ascertained from the general formula. For instance, to find the formula of pentane, it is only necessary to substitute in the general formula, $C_nH_{2n} + 2$, the value of "n," which for pentane, the fifth member of the series, is 5; thus:

$$C_5H_{2(5)} + 2;$$

or reducing,

$$C_5H_{10} + 2 = C_5H_{12}.$$

Or in case of propane, for which the value of "n" is 3, we would have

$$C_3H_6 + 2 = C_3H_8.$$

The ending of the above hydrocarbons is "ane." If one or more hydrogens are removed, radicles will be produced and their valence corresponds to the number thus taken away. Where but one H has been taken away, the "ane" of the hydrocarbon is replaced by "yl"; thus, meth*ane* produces meth*yl*.

The first three members of this series are gases, which, when mixed with air and ignited, combine with explosive force. The higher members are obtained from petroleum, and are found in such commercial substances as rhigolene, gasolene, benzine (petroleum ether), coal-oil, petrolatum, and paraffin.

The official *petrolatum*, commonly called "vaselin," used as an ointment, contains the hydrocarbons from $C_{16}H_{34}$ to $C_{20}H_{42}$; and "paraffin," from $C_{24}H_{50}$ to $C_{27}H_{56}$.

HALOGEN DERIVATIVES, OR HALOID ETHERS.

These compounds may be regarded, theoretically, as hydrocarbons in which one or more of the hydrogens have been replaced by halogen elements. For example, from methane, CH_4, there can be produced

CH_3Cl,	CH_2Cl_2,	$CHCl_3$,	and	CCl_4
Methyl chlorid.	Methylene chlorid.	Chloroform.		Carbon tetrachlorid.

They are also called monochlormethane, dichlormethane, etc., showing their relation to methane. Only those substances which are of medicinal importance will be considered.

Methane Trichlorid, *Chloroform* ($CHCl_3$; Molecular Weight, 118).—Made by the action of chlorinated lime upon alcohol. It is a bright, clear, colorless liquid, of an ethereal odor, and burning, sweet taste. It is non-inflammable.

Medicinal Properties and Uses.—Irritant, anesthetic, stimulant, narcotic, and rubefacient. Dose, 2 to 20 minims.

Preparations Containing Chloroform.—*Chloroform-water*, a saturated solution; *chloroform liniment*, 30 per cent.; *chloroform emulsion*, 4 per cent. by volume; *spirits of chloroform*, 6 per cent. by volume.

When chloroform is used as an anesthetic it must be pure. It should never be administered in the presence of gas light, as a poisonous compound is formed; nor to those suffering with weak heart.

Toxicology.—Irregular, shallow, stertorous breathing and dilated pupils. If swallowed, the stomach must be emptied by pump or siphon or emetics. Lower the head and pull forward the tongue, artificial respiration, electricity, hot and cold douche, ammonia by inhalation, friction, heat, brandy, atropin and strychnin.

Methane Tri-iodid, *Iodoform* (CHI_3; Molecular Weight, 391).—Made by a process similar to that for making chloroform. It occurs in small yellow crystals with disagreeable characteristic odor, containing nearly 97 per cent. of iodin.

Medicinal Properties and Uses.—Antiseptic and in-

creases appetite. Dose, 1 to 3 gr. The ointment is official, containing 10 per cent. of iodoform.

Methane Tribromid, *Bromoform* ($CHBr_3$; Molecular Weight, 253).—A colorless liquid, specific gravity 2.808, resembling chloroform.

Medicinal Properties.—Anesthetic and antispasmodic. Dose, 2 to 5 minims, best given in the form of emulsion, as bromoform is insoluble in water.

Monochlorethane, *ethyl chlorid* (C_2H_5Cl; Molecular weight, 64), is a liquid, boiling at 13° C. It comes on the market in small tubes. The heat of the hand is sufficient to vaporize it. It is used both as a general and local anesthetic. In the latter case the parts are frozen by the rapid evaporation, producing a white spot.

ALCOHOLS

Alcohols are aliphatic hydrocarbons in which one or more of the hydrogens have been replaced by the radicle hydroxyl, $(\overset{|}{O}H)$. They are termed monatomic, diatomic, etc., according to the number of $(\overset{|}{O}H)$'s it may contain.

Methyl Alcohol, *Methyl Hydroxid; Wood Alcohol; Wood Naphtha* (CH_3OH; Molecular Weight, 32).—This is produced when wood is subjected to destructive distillation. It is a colorless liquid. When pure, it is practically without odor, but, as found in commerce, it possesses a very disagreeable odor. It is used as a solvent for fats, oils, resins, and some alkaloids. Under

the name of "Columbian spirit" a pure commercial article is found. It is frequently used in preparations for internal use, and causes blindness.

Ethyl alcohol, *ethyl hydroxid; grain alcohol* (C_2H_5OH; Molecular weight, 46), is obtained by fermentation of saccharine substances, subsequently distilled to obtain it in concentrated form. The official alcohols are: *Alcohol*, containing 95 per cent. by volume of ethyl hydroxid; *Alcohol dilutum*, about 49 per cent.; *Alcohol absolutum*, about 99 per cent. When alcohol absolutum is first made it contains 100 per cent., but it readily absorbs moisture from the air.

Ethyl alcohol is a light, colorless liquid, with a pleasant odor. When mixed with water it produces an elevation of temperature and a contraction in volume.

Medicinal Properties and Uses.—Stimulant, depressant, astringent, and antiseptic. It at first raises the body-heat, then lowers it; hence its use in febrile conditions.

Alcohol is prepared from substances containing starch, but before this can be accomplished the starch must first be changed into glucose and levulose by the action of the ferment, *diastase:*

$$\underset{\text{Starch.}}{2C_6H_{10}O} + H_2O = \underset{\text{Glucose.}}{C_6H_{12}O_6} + \underset{\text{Levulose.}}{C_6H_{12}O_6}$$

The action of the ferment *Saccharomyces cerevisiæ*, found in yeast, then converts the sugars into alcohol.

$$C_6H_{12}O_6 = 2C_2H_5OH + 2CO_2$$

Beer is an infusion of malt and hops, and contains 2 to 4 per cent. of alcohol. Wines are fermented grape-juice, containing from 10 to 14 per cent. of alcohol. Sweet wines contain undecomposed sugar; in dry wines all the sugar has been converted into alcohol. Whisky is fermented grain; brandy, a distillate of wine; rum, fermented molasses. These contain from 40 to 50 per cent. of alcohol.

Glycerin, *glycerol* ($C_3H_5(OH)_3$; Molecular weight, 92), is obtained by the action of alkalis or superheated steam upon fats. It is a clear, colorless, syrupy liquid, with a sweet, warm taste. It is very hygroscopic. When acted upon by HNO_3 it produces nitroglycerin, $C_3H_5(NO_3)_3$, which is explosive, a 1 per cent. alcoholic solution forming *spirits nitroglycerin*, which is used as a cardiac sedative in 1-drop doses.

Medicinal Properties and Uses.—Glycerin is emollient, laxative, and solvent.

Official Preparations of Glycerin.—Glycerin suppositories contain 45 gr. of glycerin in each; *glycerite of phenol*, 20 per cent. phenol; *glycerite of tannic acid*, 20 per cent.; *glycerite of boroglycerini*, 50 per cent.

Fats are compound ethers, or esters, of the higher fatty acids, with the radicle glyceryl, $(\overset{|||}{C_3H_5})$. When liquid at the ordinary temperature they are called oils. The consistency of fats depends upon the fatty acids they contain and the proportion of each. Those containing the larger quantity of stearic acid are solid;

while those with oleic acid in excess are liquid (see page 136):

$C_3H_5(C_{18}H_{33}O_2)_3$ Olein, liquid. $C_3H_5(C_{17}H_{33}O_2)_3$ Palmatin, semiliquid. $C_3H_5(C_{18}H_{35}O_2)_3$ Stearin, solid.

Soaps are metallic salts of the higher fatty acids, and result when fats are acted upon by alkalis, glycerin being produced at the same time:

$$\underset{\text{Olein.}}{C_3H_5(C_{18}H_{33}O_2)_3} + 3NaOH = \underset{\substack{\text{Sodium oleate or}\\ \text{Castile soap.}}}{3Na(C_{18}H_{33}O_2)} + C_3H_5(OH)_3$$

The soaps of the alkalis are soluble, while those of the other metals are insoluble. The potassium soaps are soft soaps, and the soda soaps are hard.

Soft soap was formerly of a green color and called "green soap"; and its solution in alcohol, flavored with oil of lavender, or *Linimentum sapo mollis*, sometimes called tincture of green soap, is used as a detergent prior to surgical operations. *Sapo*, or Castile soap, is a constituent of *soap liniment* and *soap plaster*. A solution of Castile soap added to lead acetate forms the *lead plaster* of pharmacy.

ALDEHYDS

Theoretically considered, an aldehyd contains 2 atoms of hydrogen less than an alcohol. The name is derived from *Alcohol dehydrogenated*, two hydrogens being removed by oxidation of the alcohol:

$$C_2H_5OH - 2H = \underset{\text{Acetic aldehyd.}}{C_2H_4O} \text{ or } C_2H_5OH + O = C_2H_4O + H_2O$$

Aldehyds contain the characteristic radicle $(\overset{|}{C}HO)$ linked to a hydrocarbon radicle or H: $\underline{CH_3CHO}$ or

HCHO. The name of the aldehyd is not taken from the radicle with which the (CHO) is combined, but from the name of the acid produced by the oxidation of the aldehyd. For example, when $CH_3(CHO)$ is oxidized, acetic acid is formed and the aldehyd is called acetic aldehyd:

$$\underset{\text{Acetic aldehyd.}}{CH_3CHO} + O = \underset{\text{Acetic acid.}}{CH_3COOH}$$

Formaldehyd (HCHO or CH_2O; Molecular Weight, 30).—Prepared from methyl alcohol by oxidation:

$$CH_3OH + O = HCHO + H_2O$$

The gas thus prepared is passed into water until it contains 37 per cent. and constitutes the *formaldehyd solution* of the U. S. P. It is used as a disinfectant and frequently used unlawfully as a preservative for milk.

Its presence can be readily shown by placing in a test-tube H_2SO_4 and pouring milk carefully on top, in such a manner as not to mix them, and so as to form two distinct layers. The acid should contain a slight trace of iron. A purple color will develop in the presence of formaldehyd.

Paraldehyd ($C_6H_{12}O_3$; Molecular Weight, 132).—Made by the condensation of 3 molecules of acetic aldehyd:

$$3CH_3CHO = C_6H_{12}O_3$$

It is a colorless liquid, with a sharp, burning taste. It is a hypnotic in doses of 15 to 60 minims in syrup, largely diluted.

Trichloraldehyd, *Chloral Hydrate* ($CCl_3CHO.H_2O$; Molecular Weight, 164).—When Cl acts upon alcohol, several changes take place, finally resulting in chloral, which, when water is added to it, forms the crystalline chloral hydrate. It is soluble in water, alcohol, and ether; has an aromatic odor; and liquefies when triturated with camphor, menthol, or phenol. Caustic alkalis decompose it into chloroform.

Medicinal Properties and Uses.—Externally it is antiseptic, vesicant, and anodyne; internally, soporific, hypnotic, and general depressant. Dose, 5 to 20 gr.

Toxicology.—Give emetics; wash out the stomach; weak solution of potassium or sodium hydrate; stimulants.

KETONES

Ketones are compounds containing the characteristic radicle carbonyl, (CO), linked to two hydrocarbon radicles. These radicles may be of the same kind or of different kinds. The ending "*one*" indicates a ketone.

CH_3COCH_3	$CH_3COC_2H_5$
Dimethyl ketone.	Methyl-ethyl ketone.

Acetone, *Dimethyl Ketone* (CH_3COCH_3 or C_3H_6O; Molecular Weight, 58).—This substance is a liquid, prepared by heating calcium acetate. It is used in pharmacy as a solvent in the preparation of oleoresins, and also for making chloroform and iodoform. It is found in the urine in acetonurea (*q. v.*).

SULPHUR DERIVATIVES

If the oxygen of a monatomic alcohol is replaced by sulphur, a **mercaptan,** or sulphur alcohol, is produced:

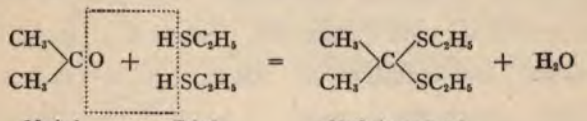
C_2H_5OH	C_2H_5SH
Ethyl alcohol.	Ethyl mercaptan.

Upon oxidation they produce sulphonic acid compounds·

$$C_2H_5SH + 3O = C_2H_5SO_2.OH$$

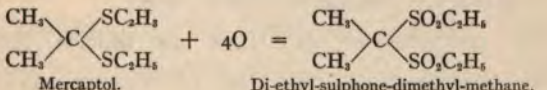
Ethyl mercaptan. — Ethyl sulphonic acid.

Mercaptans form condensation products with ketones called **mercaptols:**



Methyl Ketone. — Ethyl mercaptan. — Methyl mercaptol.

Mercaptols, when oxidized, produce compounds that are used as hypnotics:



Mercaptol. — Di-ethyl-sulphone-dimethyl-methane, "or sulphonal."

If ethyl-methyl ketone were used at the start, the product would have been "trional." The dose of these compounds is from 15 to 30 gr.

ETHERS

Others are oxids of hydrocarbon radicles or hydrocarbon radicles linked to oxygen. They are divided

into simple and mixed ethers. Simple ethers contain the same radicles, as CH_3OCH_3 (Dimethyl oxid.); and the mixed ethers contain different radicles, as $CH_3OC_2H_5$ (Methyl-ethyl-ether.)

Ethyl Ether, *Ethyl Oxid; Sulphuric Ether* ($(C_2H_5)_2O$).—This is made by the action of H_2SO_4 upon alcohol, the process taking place in two steps:

$$C_2H_5OH + H_2SO_4 = \underset{\text{Ethyl sulphuric acid.}}{C_2H_5HSO_4} + H_2O;$$

then,

$$C_2H_5HSO_4 + C_2H_5OH = (C_2H_5)_2O + H_2SO_4$$

Medicinal Properties and Uses.—Externally, irritant, local anesthetic, and refrigerant. Internally, anesthetic, stimulant, and carminative. Dose, 5 to 60 minims.

Ether anesthesia is more of a renal and bronchial irritant than chloroform, and also likely to produce vomiting, and its first stage of stimulation is longer than with chloroform.

Toxicology.—Similar to chloroform.

Two preparations of ether are official: *Spirits of ether*, containing 32.5 per cent. of ether in alcohol; and the *compound spirits of ether*, or *Hoffmann's anodyne*, containing, in addition to the above, 2.5 per cent. of ethereal oil.

Compound Ethers.—These correspond to metallic oxygen salts in which the metal has been replaced by a hydrocarbon radicle:

CH_3COOH	CH_3COONa	$CH_3COOC_2H_5$
Acetic acid.	Sodium acetate.	Ethyl acetate.

They are not ethers, notwithstanding the name, as can be seen from the formula, since they are not oxids; and the term "ether" is given to them owing to their ethereal properties. A few of the compound ethers do not possess these properties.

Acetic Ether, *Ethyl Acetate* ($CH_3COOC_2H_5$; Molecular Weight, 88).—Made by the action of acetic acid upon ethyl alcohol:

$$C_2H_5OH + CH_3COOH = CH_3COOC_2H_5 + H_2O$$

This possesses a very pleasant odor, and is used principally as a flavoring agent.

Ethyl Nitrite ($C_2H_5NO_2$; Molecular Weight, 75).—Made by the action of H_2SO_4 upon sodium nitrite in the presence of alcohol.

A 4 per cent. solution of it, by weight, in alcohol forms the official *spirits of niter.* Spirits of niter is a diffusible stimulant, stomachic, carminative, diaphoretic, and diuretic. Dose of the spirit, 1 to 2 drams.

Amyl Nitrite ($C_5H_9NO_2$; Molecular Weight, 115).—This is made in a manner similar to the above, except that amyl alcohol is used instead of ethyl. It is a liquid insoluble in water, soluble in alcohol. It is found in pharmacy in small glass pearls containing 5 minims. The pearls are broken in a handkerchief and their contents inhaled.

Medicinal Properties and Uses.—Sedative, depressant, antispasmodic, and anodyne. Given internally in doses of ½ to 1 minim.

Other Compound Ethers.—*Methyl salicylate*, artificial oil of wintergreen, used as a flavoring agent. The natural oil is used in the treatment of rheumatism.

Glyceryl trinitrate, *nitroglycerin*, and *glyceryl borate* have already been taken up (*q. v.*).

ORGANIC ACIDS

These contain the characteristic radicle, carboxyl (CO.OH), linked to a hydrocarbon radicle or H. If they contain only one carboxyl, they are termed monobasic; if two, dibasic, etc.:

$HCOOH$	$CH_3.COOH$	$CH_2(COOH)_2$
Formic acid.	Acetic acid.	Malonic acid.

Monobasic Fatty Acids.—They have the general formula of CnH_2nO_2, and form homologous series similar to all the preceding classes of carbon compounds.

Name.	Formula upon the carboxyl type.	General molecular formula.
Formic	HCO_2H	CH_2O_2
Acetic	CH_3CO_2H	$C_2H_4O_2$
Propionic	$C_2H_5CO_2H$	$C_3H_6O_2$
Butyric	$C_3H_7CO_2H$	$C_4H_8O_2$
Valeric	$C_4H_9CO_2H$	$C_5H_{10}O_2$
Caproic	$C_5H_{11}CO_2H$	$C_6H_{12}O_2$
Palmitic	$C_{15}H_{33}CO_2H$	$C_{17}H_{34}O_2$
Stearic	$C_{17}H_{35}CO_2H$	$C_{18}H_{36}O_2$

Some of these acids are made by the oxidation of the corresponding alcohol.

They are called "fatty acids" on account of the large number of them found in fats.

Formic Acid (HCO_2H, CH_2O_2; Molecular Weight, 46).—Name derived from *formica*, the ant, being found in ants. It is made artificially by heating oxalic acid with glycerin.

Acetic Acid (CH_3CO_2H, $C_2H_4O_2$; Molecular Weight, 60).—Prepared by the oxidation of alcohol, as in the souring of wine. Also by destructive distillation of wood and purified. It is found in many plants and certain animal secretions. Three acetic acids are official: Glacial acetic acid, 99 per cent.; acetic acid, 36 per cent.; dilute acetic acid, 6 per cent. It is a liquid with a characteristic odor, soluble in water, and forms, with metals, the acetates, all of which are soluble in water. Vinegar is a solution containing about 4 per cent. of acetic acid, made by the oxidation of alcohol or fruit juices, such as wine or cider.

Official Acetates.—*Solution of ammonium acetate*, "spirit of Mindererus," contains 7 per cent. ammonium acetate; *solution of iron and ammonium acetate*, Basham's mixture; lead acetate; solution of subacetate of lead; potassium acetate.

Butyric Acid ($C_3H_7CO_2H$, $C_4H_8O_2$).—This is found in rancid butter and cheese. It is present in the stomach during certain forms of indigestion. Combined with ethyl or amyl radicles, it forms compound ethers used for flavoring.

Valeric Acid ($C_4H_9CO_2H$, $C_5H_{10}O_2$; Molecular Weight, 102).—This acid is a constituent of valerian root, hence

the name. It is also found in the perspiration. It is a liquid, has an offensive odor, and is soluble in alcohol. Both the zinc and ammonium salts are official.

Stearic Acid ($C_{17}H_{35}CO_2H$, $C_{18}H_{36}O_2$; Molecular Weight, 284).—This is a constituent of the solid fats, such as tallow, combined with the radicle glyceryl, $(C_3H_5)^{'''}$. It is used in the preparation of candles and also for making the official *glycerin suppositories*.

Oleic Acid ($C_{17}H_{33}CO_2H$, $C_{18}H_{34}O_2$; Molecular Weight, 282).—This acid does not belong to the fatty acid series, but is "isologous" to it, that is, it has two atoms of hydrogen less than the corresponding acid of the fatty acid series. It is a constituent of fatty oils; combines with metals and alkaloids to form the "oleates," and is used for dermic medication.

Official Oleates.—Atropin, 2 per cent.; cocain, 5 per cent.; mercury, 25 per cent. of mercury oxid; quinin, 25 per cent.; veratrin, 2 per cent.

DIBASIC ACIDS

Name.	Molecular formula.	Formula upon the carboxyl type.
Oxalic	$C_2H_2O_4$	$(CO_2H)_2$
Malonic	$C_3H_4O_4$	$CH_2(CO_2H)_2$
Succinic	$C_4H_6O_4$	$C_2H_4(CO_2H)_2$

While from the chemical viewpoint these acids present some interesting features, the only one of medicinal importance is oxalic acid.

Oxalic Acid ($H_2C_2O_4$, $(CO_2H)_2$; Molecular Weight, 90).—In nature this acid is widely distributed in plants

as the potassium, sodium, and calcium salts; in rhubarb, sorrel, tomatoes, and, in animal secretions as guano and urine. It is prepared commercially by heating sawdust with KOH, adding lime, and precipitating with H_2SO_4. It is a crystalline substance, soluble in water, and poisonous. It is used as a cleaning agent and to remove ink- and iron-stains.

Toxicology.—Give calcium salts, as chalk; plaster from the wall, which forms with it the insoluble calcium oxalate, CaC_2O_4; followed by emetics and demulcent drinks.

Hydroxy Acids.—These are acids in which one or more hydrogens of the nucleus has been replaced by the radicle (OH).

CH_3CO_2H	$CH_2(OH)CO_2H$
Acetic acid.	Monohydroxy acetic acid.

Several of the hydroxy acids are used in medicine, and are found in the body, and these will be referred to under Physiologic Chemistry.

Lactic Acid, *Hydroxypropionic Acid* ($HC_3H_5O_3$, $C_2H_4(OH)CO_2H$; Molecular Weight, 90).—The formula of propionic acid, as has been shown under the Fatty Acids, is $C_2H_5CO_2H$. If one hydrogen of the nucleus or (C_2H_5) is replaced by (OH), lactic acid results. Three "isomeric"[1] lactic acids exist, but space in a work of this kind will not permit of an extended description.

[1] See page 144.

The ordinary lactic acid is present in the gastric juice, and is produced during milk fermentation. It is also contained in "sauer kraut." The official acid contains 75 per cent. Sarcolactic acid, an isomer of the above, occurs in the muscles and in meat extracts, and its presence induces cadaveric rigidity.

Malic Acid $C_2H_3(OH)(CO_2H)_2$.—This is monohydroxy succinic acid. It is found in the juice of many fruits, as apples, currants, cherries, etc.

Tartaric Acid $H_2C_4H_4O_6$, $C_2H_2(OH)_2(CO_2H)_2$; Molecular Weight, 150.—Four tartaric acids are possible. The official acid is found in vegetables and fruits. In the grape it exists as potassium bitartrate, which is deposited in the wine-cask during fermentation. The impure cream of tartar is purified, and treated with lime, forming calcium tartrate, from which tartaric acid is produced by adding H_2SO_4.

The acid is contained in *Seidlitz powders* and the effervescing salts. The official tartrates are: *Potassium bitartrate*, "cream of tartar"; *sodium and potassium tartrate*, "Rochelle salts"; *antimony and potassium tartrate*, "tartar emetic," and *iron and potassium tartrate*.

Citric Acid $H_2C_6H_6O_7.H_2O$, $C_3H_4(OH)(CO_2H)_3.H_2O$; Molecular Weight, 210.—This is a tribasic acid, found in oranges, lemons, and other fruits.

Like tartaric acid, it enters into the composition of the effervescing salts. It forms, with metals, the citrates. The official citrates are those of potassium, sodium,

lithium, bismuth, bismuth and ammonium, iron, iron and ammonium, iron and quinin, and solution of magnesium.

AMINO-ACIDS

These are derived, theoretically from acids, similar to the hydroxy acid, by replacement of H of the nucleus by the radicle (NH_2):

CH_3CO_2H	$CH_2(NH_2)CO_2H$
Acetic acid.	Amino-acetic acid.

Aminoformic Acid, *Carbamic Acid* (NH_2CO_2H).—The ammonium salt of this acid is a constituent of the artificial ammonium carbonate (*q. v.*).

Urethans are ethereal salts, or compound ethers of this acid.

Ethyl carbamate, *urethane* ($NH_2CO_2C_2H_5$), is a crystalline powder used as a hypnotic, in doses of 10 to 40 gr.

Amino-acetic Acid, *Glycocoll; Glycin* ($CH_2NH_2CO_2H$).—This is obtained by decomposition of hippuric acid:

$$\underset{\text{Hippuric acid.}}{C_9H_9NO_3} + H_2O = CH_2NH_2CO_2H + C_7H_6O_2$$

Amino-acetic acid is also made by the action of alkalis upon glycocholic acid, the sodium salt of which is a constituent of bile:

$$\underset{\text{Glycocholic acid.}}{C_{26}H_{43}NO_6} + H_2O = CH_2NH_2CO_2H + \underset{\text{Cholic acid.}}{C_{24}H_{40}O_5}$$

Associated with sodium glycocholate, there is another sodium salt combined with taurocholic acid, and, under

similar conditions, it splits up into cholic acid and taurin:

$$\underset{\text{Taurocholic acid.}}{C_{26}H_{45}NO_7S} + H_2O = \underset{\text{Cholic acid.}}{C_{24}H_{40}O_5} + \underset{\text{Taurin.}}{C_2H_7NO_3S}$$

These are known as the "biliary salts," and are found to the extent of 1 per cent. in the bile.

These salts are now on the market in tabloid form, and are used to increase the bile-salts in the intestines.

Amido- or Amino-acids of Physiologic Importance.—amidocaproic acid (leucin), amidosuccinic acid (aspartic acid), para-oxyphenylamidopropionic acid (tyrosin), amidopyrotartaric acid (glutamic acid), amidopropionic acid (alanin), creatin, and creatinin.

AMINS

These may be considered as ammonia in which one or more of its hydrogens have been replaced by hydrocarbon radicles. If one H is replaced, a *primary* or *normal amin* is formed; if two, a *secondary* or *di-amin;* if all, a *tri-* or *tertiary amin.*

$N{-H \atop -H \atop -H}$ or NH_3,
Ammonia.

$N{-H \atop -H \atop -CH_3}$ or NH_2CH_3,
Methyl amin,
a primary amin.

$N{-H \atop -C_2H_5 \atop -C_2H_5}$ or $NH(C_2H_5)_2$,
Di-ethyl amin,
a secondary amin.

$N{-C_3H_7 \atop -C_3H_7 \atop -C_3H_7}$ or $N(C_3H_7)_3$
Tripropyl amin,
a tertiary amin.

Amids.—These differ from amins, in that the H in this case is replaced by *acid radicles* instead of hydro-

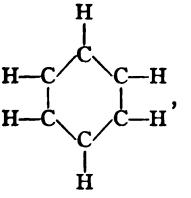
carbon radicles. The acid radicle referred to in this case is the organic acid, without the (OH) of the carboxyl radicle.[1]

Urea, ***Carbamid*** (N_2H_4CO or $\begin{matrix}NH_2\\NH_2\end{matrix}\!\!>\!CO$).—This is an amid of carbonic acid, $\begin{matrix}HO\\HO\end{matrix}\!\!>\!CO$, the hydroxyls having been replaced by (NH_2). It is found in the urine and blood of all mammalia. (See Urine.)

Ureids are urea in which one or more of the H have been replaced by acid radicles. These compounds form important synthetic medicinal substances, among which are malonyl urea and di-ethyl malonyl urea, or veronal; a hypnotic, given in 5- to 10-gr. doses.

AROMATIC, CLOSED CHAIN, OR CYCLIC HYDROCARBONS

The starting-point of this class of hydrocarbons is *benzene* or *benzole*, C_6H_6. The graphic formula is



often diagrammatically expressed by this sign, . This group, like the hydrocarbons of the paraffin series,

[1] $CH_3CO.OH$ ($CH_3CO.$)
Acetic acid. Acid radicle of acetic acid, called "acetyl."

$HCO.OH$,	$HCO.NH_2$,	$CH_3CO.OH$,	$CH_3CO.NH_2$
Formic acid.	Formamid.	Acetic acid.	Acetamid.

has a large number of *homologues*. Only two of them need be mentioned here:

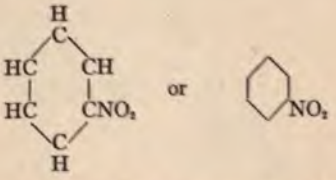
C_6H_6,	$C_6H_5.CH_3$ or C_7H_8,	$C_6H_4(CH_3)_2$ or C_8H_{10}
Benzene.	Toluene.	Xylene.

Benzene, *Benzole* (C_6H_6; Molecular Weight, 78).—This is the most important member of the series, and is obtained from the distillate of *coal-tar*. It is a colorless, highly volatile liquid, with an aromatic odor, and is a solvent for fats, oil, and resins.

Nitrobenzene, *Oil of Mirbane* ($C_6H_5NO_2$; Molecular Weight, 123).—This is a very poisonous substance, acting as a cardiac depressant when excessively inhaled, and is used as a flavoring agent, resembling somewhat oil of bitter almonds. It is made by treating benzene with HNO_3:

$$C_6H_6 + HNO_3 = C_6H_5NO_2 + H_2O$$

Graphic formula:



Hydroxybenzenes or Phenols.—Phenols are alcohols of the benzene series. Generally considered, *alcohols* are derived from the aliphatic hydrocarbons, while *phenols* are those obtained by the replacement of one or more H by (OH) in benzene.

Phenol, *Carbolic Acid* (C_6H_5OH; Molecular Weight,

94).—Obtained from the distillate of *coal-tar* and subsequently purified.

It is a colorless solid, with a characteristic odor; melts at 35° C.; and if diluted with 5 per cent. of water remains liquid. The *liquefied phenol* of the U. S. P. is made by adding to 9 parts, by weight, of melted phenol 1 part of water.

Medicinal Properties and Uses.—Antiseptic, germicide, anesthetic, and poisonous. Dose, 1 minim. It is contained in *Glyceritum phenolis*, 20 per cent.; and in *Unguentum phenolis*, 3 per cent., incorporated with petrolatum.

Toxicology.—White of egg; alcohol, followed by emetics. Magnesium or sodium sulphate may also be given, with which phenol produces the phenolsulphonates.

Tests of Phenol.—It coagulates albumin and collodion. With ferric chlorid, an amethyst solution is obtained.

Nitrophenols.—When HNO_3 acts upon phenol, a mono-, di-, or tri-nitrophenol is obtained, depending upon conditions.

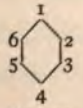
Trinitrophenol, *Picric Acid* ($C_6H_2(NO_2)_3OH$; Molecular Weight, 229).—This is a yellow crystalline substance, with a very bitter taste, forming compounds which are explosive. It is used for dyeing silks and tissues, as a precipitant for albumin and alkaloids, and as a counter-irritant for burns. In this latter use it has been stated to be sometimes followed by poisonous effects.

Cresols.—These are defined as either homologous phenols or hydroxytoluenes, which can be shown diagrammatically as follows. Starting with phenol, we have, , by adding CH_2 we form , or by starting with toluene, , and replacing one H by (OH), we obtain , which will be seen to be of the same composition as the first.

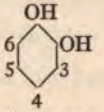
ISOMERIC COMPOUNDS OF THE AROMATIC HYDROCARBONS

Among the carbon compounds will be found many instances where substances exist having the same composition as others, but which possess different physical properties, and to which the term "isomerism" is given.

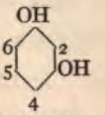
If two H of benzene are replaced, it has been found that three distinctive compounds may be produced, all with the same chemical composition, but each possessing different physical properties. For convenience, each H of benzene will be designated by a different number. If numbers 1 and 2 are replaced, an "ortho" compound will be formed, frequently expressed as 1 : 2; if 1 and 3 are replaced, a "meta," 1 : 3; and if 1 and 4 is the position of the substitution, a "para," or 1 : 4:



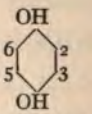
Benzene.



"Ortho" or 1 : 2.



"Meta" or 1 : 3.



"Para" or 1 : 4.

The official *cresol* is a mixture of the three isomeric cresols. They are similar in properties to phenol, but less poisonous. Mixed with soap solution, they are used by the surgeon, under various names, as lysol, creolin, kresol, kreso, etc.

Dihydroxy Benzenes ($C_6H_4(OH)_2$).—From the formula of these compounds it will be seen that since two of the H of benzene has been replaced by (OH), three isomeric compounds of the above composition can exist. All of these are known and have extensive use; only one, however, which is of medicinal importance, will be taken up here.

Resorcinol, *Resorcin; Metadihydroxy Benzene* ($C_6H_4(OH)_2$, 1 : 3; Molecular Weight, 110).—This is made by fusing different resins with alkalis. It possesses properties somewhat allied to phenol. It is antiseptic, antipyretic, and depressant. Used internally in fermentative dyspepsia and intestinal troubles in doses of 2 to 5 gr.

Creosote.—This is obtained from wood-tar, and is a liquid with a smoky odor, soluble in alcohol, ether, and chloroform.

Medicinal Properties and Uses.—Stimulant, antiseptic, and parasiticide.

Used in phthisis and bronchial affections in doses of 1 to 10 minims. *Aqua creosote* contains 1 per cent. of it. Creosote owes its virtues to guaiacol and cresol, the former being contained in it to the extent of from 60 to 90 per cent.

Guaiacol, *monomethyl catechin,* is obtained either from creosote, of which it is a natural constituent, or prepared synthetically. It is a crystalline solid or a colorless liquid, with a strong aromatic odor. Used like creosote, in 1- to 10-minim doses.

Pyrogallol, *Pyrogallic Acid; Trihydroxy Benzene* ($C_6H_3(OH)_3$; Molecular Weight, 126).—Obtained by heating gallic acid, hence its name. Used as a developing agent in photography. It is poisonous.

Benzaldehyd, *Artificial Oil of Bitter Almonds* (C_6H_5CHO; Molecular Weight, 106).—This occurs in the natural oil of bitter almonds, which differs from the artificial oil in containing HCN, while the artificial does not. It is used as a flavoring agent.

Benzoic Acid ($C_6H_5CO_2H$, $HC_7H_5O_2$; Molecular Weight, 122).—This is found in benzoin and other resins, combined with other substances. It is found in the urine of herbivorous animals. (See Hippuric Acid.)

It is prepared commercially from toluene by oxidation:

$$C_6H_5CH_3 + 3O = C_6H_5CO_2H + H_2O$$

Benzoic acid combines with the alkalis forming the benzoates. Those official are: Ammonium, lithium, and sodium, all of which are soluble. The acid is but slightly soluble in water; soluble in alcohol and ether.

Tests for Benzoates.—The soluble benzoates form,

with solution of ferric chlorid, $FeCl_3$, a reddish-brown precipitate.

Salicylic Acid ($C_6H_4(OH)CO_2H$, $HC_7H_5O_3$; Molecular Weight, 138).—From the structural formula it will be seen that this is a hydroxybenzoic acid. It is found in some plants, and is also found as methyl salicylate in oil of wintergreen. The acid obtained from the oil is called "natural salicylic acid." Salicylic acid of commerce is obtained from phenol, and it has been recently shown, by the researches of the Council of Pharmacy and Chemistry of the American Medical Association, that the average salicylic acid of commerce today is free of deleterious impurities. It is but slightly soluble in water, soluble in alcohol and ether. It is used in medicine combined with the alkalis, the salts of which are soluble.

Medicinal Properties.—The acid and salicylates are antiseptic, antipyretic, and analgesic. Used principally in rheumatism. Dose, 5 to 20 gr.

Phenyl Salicylate, *Salol* ($C_6H_5(C_7H_5O_3)$; Molecular Weight, 214).—Made by action of dehydrating agents upon mixture of phenol and salicylic acid. It is antiseptic, antipyretic, and antirheumatic. Dose, 5 to 30 gr.

Aspirin. *Acetyl Salicylic Acid* ($C_6H_4(O)(CH_3CO.)$-CO_2H).—This is a derivative of salicylic acid, used as an antipyretic and analgesic, in doses of 5 to 10 gr. It exists in the form of colorless crystals, slightly soluble in water, and freely soluble in alcohol and ether. The

action of boiling water or alkalis decompose it, liberating acetic acid.

Official Salicylates.—Sodium, lithium, and strontium salicylates, and bismuth subsalicylate.

Test.—Salicylic acid and salicylate give with $FeCl_3$ a purple color.

Gallic Acid, *Trihydroxy Benzoic Acid* ($C_6H_2(OH)_3$-$CO_2H.H_2O$, $HC_7H_5O_5.H_2O$; Molecular Weight, 188).—This acid is obtained from nutgalls by the action of a specific ferment upon the tannin contained in the nutgalls. It is a crystalline substance, very astringent. Bismuth subgallate, or "dermatol," is a yellow, insoluble powder, which is official and made from gallic acid.

Tannic Acid ($HC_{14}H_9O_9$; Molecular Weight, 322).—This acid is obtained from nutgalls and a host of other substances. By fermentation it is converted into gallic acid. Tannic acid precipitates alkaloids and gelatin and coagulates albumin, and produces with iron a dark-colored solution or precipitate. It differs from gallic acid, which does not precipitate the above-mentioned substances, and which, with ferric salts, produces a bluish-black precipitate.

Anilin, *Phenylamin* ($C_6H_5NH_2$).—The aromatic hydrocarbons also combine with (NH_2), like the aliphatic hydrocarbons, to form the amins. Anilin is made by the action of nascent H upon nitrobenzene:

$$C_6H_5NO_2 + 6H = C_6H_5NH_2 + 2H_2O$$

It is the starting-point of a class of substances known as the "anilin dyes."

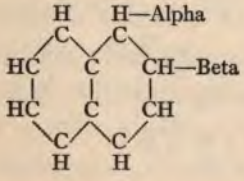
Acetanilid, *Antifebrin; Phenyl Acetamid* ($C_6H_5NH(CH_3CO)$).—This is made by the action of glacial acetic acid upon anilin:

$$C_6H_5NH_2 + CH_3CO.OH = C_6H_5NH(CH_3CO) + H_2O$$

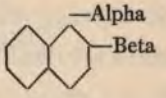
It is an antipyretic, analgesic, and antispasmodic in doses of 5 to 10 gr.

Naphthalene ($C_{10}H_8$).—This is a white, crystalline solid of characteristic odor, with burning, aromatic taste, poisonous, insoluble in water, soluble in alcohol and ether. It is obtained from coal-tar. "Moth balls" are composed wholly of naphthalene. It is an antiseptic, vermifuge, and parasiticide. Dose, 2 to 5 gr.

It may be regarded, theoretically, as a combination of two benzene molecules:

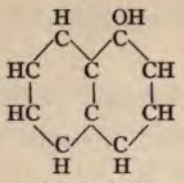


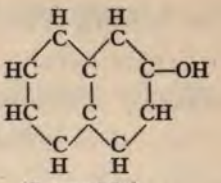
or



Naphthols ($C_{10}H_7OH$).—These bear the same relation to naphthalene as phenols do to benzene. Two isomers of the mononaphthols are possible.

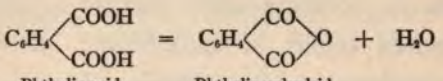
If the H in the alpha position, as shown in the foregoing diagram, is replaced by (OH), an alpha-naphthol is formed; if in the beta position, beta-naphthol results:


Alpha-naphthol.


Beta-naphthol.

Beta-naphthol is official, and is used as an antiseptic, deodorizer, and antifermentative in doses of 2 to 5 gr.

Phthalic Acid ($C_6H_4(CO_2H)_2$).—This is a dibasic acid called phthalic acid, because it can be obtained from naphthalene. When heated it decomposes, forming phthalic anhydrid:


Phthalic acid. Phthalic anhydrid.

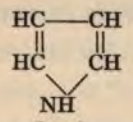
Phthalic anhydrid, when heated with H_2SO_4 and phenol, forms *phenolphthalein*.

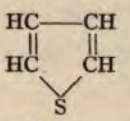
Phenolphthalein is used as an indicator in chemical work, forming with alkalis a beautiful red color, and a colorless solution with acids. It has of recent years been used as a purgative in doses of 1 to 5 gr.

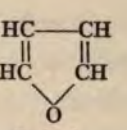
HETEROCYCLIC HYDROCARBONS

Benzene and naphthalene are representatives of the "cyclic" or "closed chain" hydrocarbons, from the formula of which it will be seen that they only contain carbon and hydrogen. When other elements are found in the chain, these compounds are called "hetero-

cyclic" or mixed chain hydrocarbons. Three different types exist:


Pyrrol.


Thiophen.


Furfurol.

Pyrrol (C_4H_4NH) is obtained from bone-oil, and an alcoholic solution treated with iodin forms tetra-iodo-pyrrol, called "iodol," which is official and used as a substitute for iodoform. It is a yellow, odorless powder:

$$C_4H_4NH + 8I = \underset{\text{Iodol.}}{C_4I_4NH} + 4HI$$

TERPENES

These consist of a group of unsaturated hydrocarbons with the general formula of $(C_5H_8)_x$, found largely in volatile oils. They are classified into various groups:

Hemiterpenes, (C_5H_8) (half).

Terpenes, $C_{10}H_{16}$.

Sesquiterpenes, $C_{15}H_{24}$ (one and a half).

Diterpenes, $C_{20}H_{32}$.

Polyterpenes, $(C_{10}H_{16})_x$.

Volatile Oils.—These are liquids obtained from all parts of plants. They are soluble in alcohol, ether, and chloroform. They differ from fats and oils in that they do not contain the radicle $(\overset{'''}{C}_3H_5)$. They produce on paper a greasy stain, which upon exposure soon disappears, while this stain with fats and oils is permanent.

They are generally lighter than water, but a few are heavier.

Terpenes produce a series of compounds known as stearoptens, of which camphor and menthol are representatives.

Camphor ($C_{10}H_{16}O$) is a white, translucent solid, soluble in alcohol, ether, chloroform, and fats. Heating with HNO_3 produces camphoric acid, $C_8H_4(CO_2H)_2$.

Medicinal Properties and Uses.—It is antispasmodic, stimulant, carminative, stomachic, diaphoretic, and sedative. Dose, 1 to 3 gr.

Preparations Containing Camphor.—Aqua camphora, 0.8 per cent.; liniment of camphor, 20 per cent., in cotton-seed oil; cerate of camphor, 2 per cent.; spirits of camphor, 10 per cent.

Menthol ($C_{10}H_{14}OH$).—This stearopten is found in oil of peppermint. Chemically it is a secondary alcohol. It occurs in white, colorless crystals, soluble in alcohol. It has a very strong odor of peppermint.

Terpin Hydrate ($C_{10}H_{18}(OH).H_2O$) is obtained by the action of HNO_3 upon turpentine. It is a white, crystalline substance, with a slight odor, insoluble in water, soluble in alcohol.

Medicinal Properties and Uses.—It is antiseptic, expectorant, diuretic, and diaphoretic. Dose, 2 to 15 gr.

CARBOHYDRATES

The term "carbohydrates" is given to a class of compounds containing, in the molecule, 6 atoms of carbon (or a multiple of six) in combination with hydrogen and oxygen, the latter elements in the proportion to form water. While this is the original classification, it can be shown that there are many compounds included under this heading in which the carbon, hydrogen, and oxygen differ in proportion from that above stated. Carbohydrates are found in plants and in animals (glycogen). They are usually designated by the suffix "ose" added to some appropriate base. Thus, lact*ose* and malt*ose* indicate milk- and malt-sugars respectively. Chemically they vary in their composition, some being aldehyds, while others are ketones. They constitute the sugars, starches, gums, and celluloses.

Cellulose, *Plant Fiber; Lignin.*—This is the framework of plants. It is also found as cotton, hemp, and flax. When treated with H_2SO_4, its structure becomes changed and it forms parchment. It is insoluble in water, but is dissolved by ammoniac solution of copper sulphate. When treated with HNO_3 it forms *gun-cotton* or *pyroxyllin*, several varieties of which are known.

When gun-cotton is added to a mixture of alcohol and ether, it dissolves and forms *collodion*, which is used in surgery and forms a protective coating. Several collodions are official: *Cantharidal collodion*, 60 per cent. cantharides, used as a blistering fluid; *styptic collodion*,

20 per cent. tannic acid; *flexible collodion*, containing Canada balsam and castor oil, to make it more pliable. A mixture of camphor and collodion, upon proper treatment, forms celluloid.

Starch.—This is obtained from various sources, and each individual kind can be distinguished by certain characteristics, under the microscope. Starch can be told chemically by the action of iodin, which produces the blue starch iodid. It is insoluble in cold water, but when boiled for a short time with water swells and forms a gelatinous mass. By the action of dilute acids starches are converted into glucose and dextrin:

$$\underset{\text{Starch.}}{3C_6H_{10}O_5} + 2H_2O = \underset{\text{Glucose.}}{2C_6H_{12}O_6} + \underset{\text{Dextrin.}}{C_6H_{10}O_5}$$

Dextrin, *British gum*, as shown above, is obtained from starch. It is soluble in water, forming mucilage, and produces with iodin a red color.

Cane-sugar, *Saccharose* ($C_{12}H_{22}O_{11}$).—This is found in certain fruits and also in sugar-cane and beets. Solutions of cane-sugar, if of sufficient concentration, do not ferment, but by the action of dilute acids or yeast cane-sugar is converted into glucose and levulose, which undergo fermentation:

$$\underset{\text{Cane-sugar.}}{C_{12}H_{22}O_{11}} + H_2O = \underset{\text{Glucose.}}{C_6H_{12}O_6} + \underset{\text{Levulose.}}{C_6H_{12}O_6}$$

Cane-sugar does not reduce Fehling's solution, while glucose and levulose do.

Lactose, *milk-sugar* ($C_{12}H_{22}O_{11}.H_2O$), is obtained by

crystallization of the whey of milk. It is a crystalline substance, soluble in water, but not possessing the sweetness of the other sugars. By fermentation it is converted into alcohol and lactic acid.

Glucose, *Grape-sugar* ($C_6H_{12}O_6$).—Originally found in grapes, honey, and acid fruits. It is obtained upon a commercial scale by the action of dilute acids upon starch. White grape-sugar is a solid. The commercial article is in the form of a thick syrup, and is largely used as a substitute for cane-sugar. It is not as sweet as cane-sugar. Glucose is found in diabetic urine. (See under Urine.)

ALKALOIDS

These are groups of nitrogenous substances possessing basic properties, found in all parts of plants, and to them the active medicinal properties of the plants are largely due. The name "alkaloid" is given them from "alkali-like," in allusion to their alkaline properties. When obtained from animals, they are termed "ptomains," and possess properties identical with those of the former. Chemically, they are either amins or amids. The former are liquid and volatile, and the latter solid and non-volatile. They combine with acids to form salts.

They are usually obtained by extraction of the drug with acidified water, and adding to this solution an alkali, which precipitates the alkaloid, which is dissolved

in some suitable solvent and crystallized. The alkaloids are nearly insoluble in water. They are soluble in alcohol, ether, chloroform, benzine, and benzene. They are precipitated by alkali hydroxids, except morphin; also by the alkaline carbonates and bicarbonates, except strychnin and veratrin; and by tannin, picric acid, mercuric chlorid, Mayer's reagent, and phosphomolybdic acid.

Toxicology.—After emptying stomach, give tannic acid or liquids containing it, like tea or coffee, followed by emetics. When the nature of the alkaloid is known, the proper physiologic antidote should be administered.

The principal liquid alkaloids are: Piperidin, $C_5H_{11}N$; nicotin, $C_{16}H_{14}N$; coniin, $C_8H_{15}N$; and spartein, $C_{15}H_{26}N_2$. The sulphate of the latter is official. It is obtained from broom tops, and is a cardiac stimulant and narcotic. Dose, $\frac{1}{6}$ to $\frac{1}{2}$ gr.

Nicotin is obtained from tobacco. It is poisonous, and has a characteristic odor. Poison is treated after general methods, giving as a physiologic antidote stimulants and nitroglycerin, $\frac{1}{100}$ gr. or more.

Coniin is obtained from poison hemlock. It has a penetrating, mouse-urine odor.

Alkaloids from Cinchona.—Cinchona bark contains from 21 to 32 alkaloids, the principal among which are quinin, quinidin, cinchonin, and cinchonidin.

They possess tonic, antipyretic, febrifuge, stomachic, and antiseptic properties. Quinin in acid solution pro-

duces a bluish fluorescence; with chlorin it turns green, upon the addition of NH_4OH.

Strychnin.—This is found in nux vomica and ignatia bean, combined with brucin and igasuric acid. It exists in the form of small crystals, and is so intensely bitter that in solutions containing 1 part to 700,000 it is still perceptible.

Medicinal Properties and Uses.—Motor excitant, tonic, stomachic, respiratory, muscle and nervous stimulant. Dose, $\frac{1}{60}$ to $\frac{1}{20}$ gr.

Toxicology.—Poisoning is characterized by tetanic spasms. The muscles of respiration are rigidly contracted with great pain and fixation of the jaws, similar to lock-jaw. Pupils contracted, with opisthotonos and ghastly grin.

Place in horizontal position in dark room, remote from all noise.

Chemical antidote, potassium permanganate with tannin and charcoal. Empty bladder to prevent absorption. Chloral, bromids, and inhalations of chloroform may be beneficial.

Tests.—Strychnin, with a small crystal of potassium dichromate and H_2SO_4, produces a play of colors—blue to purple, violet, crimson, orange, and yellow.

Opium, which is the dried juice of the poppy, contains 19 alkaloids combined with meconic, lactic, and sulphuric acids. Those principally used in medicine are morphin and codein.

Medicinal Properties and Uses.—They are poisonous, sedative, narcotic, anodyne, hypnotic, and diaphoretic. Dose: of morphin, $\frac{1}{8}$ to $\frac{1}{4}$ gr.; of codein, from $\frac{1}{2}$ to 2 gr.

Toxicology.—Poisoning by opium or its alkaloids is characterized by slow breathing, cyanosis, moist skin, and contracted, pin-hole pupils. Treatment: Follow general methods; and administer potassium permanganate for chemical antidote. Flagellation with wet towels, electricity, and artificial respiration must also be used.

Tests.—Morphin, with HNO_3, gives a blood-red color; with ferric chlorid, a blue color; and with H_2SO_4, containing a trace of formaldehyd, a deep violet color. Codein with H_2SO_4, with a trace of iron, gives a blue color.

Apomorphin Hydrochlorid.—This is a salt of an artificial alkaloid, obtained by heating morphin or codein for two hours, in sealed tubes, with HCl, to a temperature of 150° C. Upon exposure it oxidizes and should not be used. Dose: as expectorant, $\frac{1}{40}$ to $\frac{1}{20}$ gr.; as emetic, $\frac{1}{8}$ to $\frac{1}{6}$ gr.

Heroin, *Diacetyl Morphin.*—This is an artificial alkaloid, from morphin. It is a cough sedative and respiratory stimulant, neither analgesic nor hypnotic. Dose, $\frac{1}{24}$ to $\frac{1}{12}$ gr.

Atropin.—This is obtained from belladonna, or deadly nightshade. It is mydriatic, sedative, diuretic, antispasmodic, and increases peristalsis. Dose, $\frac{1}{120}$ to $\frac{1}{60}$ gr.

Toxicology.—Poisoning by atropin or belladonna is manifested by giddiness, drowsiness, incoherent speech, dryness of the mouth and throat, dilated pupils, and flushed face. Follow treatment for general alkaloidal poisoning, with opium as physiologic antidote.

Test.—Atropin, treated with HNO_3 and evaporated, produces a yellow residue, turning violet upon addition of alcoholic solution of caustic potash and a fragment of KOH. Homatropin is a synthetic alkaloid used as a substitute for atropin.

Aconitin is an alkaloid found in aconite root, combined with aconitic acid. It is a cardiac and nerve sedative, anodyne, diaphoretic, and antipyretic. Dose, $\frac{1}{640}$ to $\frac{1}{200}$ gr.

Toxicology.—Anxious countenance, clammy skin, numbness and tingling of mouth and fauces, and cardiac failure. Treatment: General methods, with strychnin.

Cocain.—This alkaloid is found in coca leaves. It is a white, crystalline powder. The hydrochlorid is soluble in water. It is anesthetic upon mucous membranes and subcutaneous tissue, but has little effect upon unbroken skin. Cerebral stimulant, tonic, diuretic, diaphoretic, and mydriatic. Dose, $\frac{1}{8}$ to 2 gr.

Toxicology.—Inhalations of ammonia or amyl nitrite, chloral, artificial respiration, and general methods.

Tests.—Solutions of cocain, with HCl and potassium dichromate, yield an orange crystalline precipitate. A

3 per cent. solution of potassium permanganate with cocain produces a violet precipitate.

Cocain solutions must not be sterilized by heat, which decomposes them. **Veratrin, hydrastin,** and **physostigmin** are alkaloids of little use.

Physostigmin, *Eserin* (an Alkaloid from Calabar Bean).—The sulphate and salicylate are official. The salicylate is used largely in ocular practice as a myotic. The alkaloids are depressants, sialagogues, purgatives, and diaphoretics. Dose, $\frac{1}{120}$ to $\frac{1}{60}$ gr.

PART III

PHYSIOLOGIC CHEMISTRY

PHYSIOLOGIC chemistry is that division of chemical science treating of changes taking place in the living organism of both animal and vegetable life. Changes occurring in the healthy organism are normal, while those produced under the influence of disease are abnormal or "pathologic." The substances generally classified under this head are proteins, fats, and carbohydrates.

PROTEINS

These form the chief part of the solid and liquid constituents of the body, such as blood, muscle, nerves, etc. Proteins are also found in small quantities in every part of plants and, in larger amounts, in seeds, such as peas, beans, etc. Proteins have not been prepared artificially. They are composed of carbon, hydrogen, nitrogen, oxygen, and salts, and may also contain sulphur, phosphorus, and iron.

Classification.—Since the exact composition of the proteins is not understood, an exact classification is impossible; two methods are adopted. The first depends

upon their source, and divides them into two classes: native proteins, which may be isolated without loss of their properties; and derived proteins, which are derived by the action of heat and reagents upon native proteins. The second method of classification is according to their composition and subdivides them into simple proteins, conjugated proteins, and derived proteins.

Simple Proteins.—These yield only alpha-amino-acids or their derivatives, and are found in muscle, albumins, globulins, and in all fluids of the body, except tears and sweat. Under the influence of HCl, the nitrogen of the protein is subdivided into four forms, viz., NH_3, amido- and di-amido-acids, and a guanidin residue. Alkalis cause the nitrogen to split off as NH_3 and a part of the sulphur to form a sulphid; the other part of sulphur forms sulphates. Hydrolytic agents, such as dilute acids and certain ferments, split the simple protein molecules into proteins of lower molecular weight; these are readily diffusible, and are no longer coagulated by heat.

Tests.—Heat some of the substance with HNO_3; a coagulation of the protein takes place.

Heller's Test.—Upon a layer of HNO_3 cautiously add a solution of protein: a white opaque ring is formed at the point of contact.

Solutions of the heavy metals coagulate proteins. This explains the use of albumin as an antidote in metallic poisoning.

Potassium ferrocyanid, picric acid, tannic acid, and trichloracetic acid also precipitate proteins.

Subdivisions of Simple Proteins.—*Albumins* are soluble in water and coagulated by heat, such as white of egg, serum-albumin of the blood and serous fluid, lactalbumin of milk, and myo-albumin of muscle.

Globulins are insoluble in water, but soluble in water containing neutral salts, and are coagulated by heat. They are found in milk, blood, and fibrinogen.

Acid and *alkaline albumins* are obtained by the action of acids or alkalis upon albumin. Syntonin, obtained during digestion, is an acid albumin.

Coagulated proteins are obtained by action of heat, enzymes, or acids on native proteins, and have been found in the liver and other glands. Fibrin is a coagulated protein formed by the action of fibrin ferment upon the fibrinogen of the blood.

Proteoses are hydrolytic products of protein. They are soluble in water and not coagulated by heat.

Peptones are somewhat similar products, and are obtained by the action of unorganized ferments upon proteins.

Conjugated or Compound Proteins.—These contain the protein molecule combined with other molecules otherwise than as a salt. Upon hydrolysis they yield the simple protein and a non-protein substance. They constitute the glycoproteins, hemoglobins, nucleoproteins, and phosphoproteins.

Glycoproteins.—These contain a carbohydrate group, capable of reducing alkaline copper sulphate solution, such as the mucins, mucoids, and chondroproteins.

Nucleoproteins.—These proteins are composed of nucleic acid combined with one or more protein molecules.

Phosphoproteins.—The proteins of this group contain a simple protein molecule combined with a substance containing phosphorus, other than nucleic acid or lecithin.

Derived Proteins.—The proteins included in this group are obtained, as the name implies, by the action of acids, alkalis, heat, or enzymes upon proteins.

MILK

Milk is a sweet, opaque, bluish-white fluid, secreted by the mammary gland of the mammalia. The composition varies in different animals, but always contains the necessary elements for the normal development of the young of any particular animal.

PERCENTAGE COMPOSITION OF NORMAL MILK
(after Holland)

	Cow.	Human.
Water	87.41	87.29
Solids, as tabulated below	12.59	12.71
Caseinogen	3.01	1.03
Albumin	0.75	1.26
Albuminoids	3.76	2.29
Fats	3.66	3.78
Milk-sugar	4.92	6.04
Ash	0.70	0.31

Its density varies from 1.029 to 1.033, and, in extreme cases, may vary between 1.018 to 1.045.

Reaction.—The reaction of human milk and that of the herbivora is generally alkaline, although it may be *amphoteric*, that is, it may be both acid and alkaline at the same time, due to the presence of acid phosphates and also secondary phosphates.

The average daily quantity secreted by a woman is 1 liter.

Standard of Strength.—Various States have different standards. The average standard of cows' milk is that it should contain not less than 13 per cent. of total solids, 3.5 per cent. of which is fat.

Preservation.—Milk may be prevented from undergoing fermentation by refrigeration or by sterilization. If subjected to a temperature below 59° F., it may be kept several days without change. Cold does not preserve milk indefinitely; nor will it kill bacteria or alter the toxalbumins it may have contained, but will retard their development.

The best method of preservation is sterilization. It has been conclusively proved that at a temperature of 154° to 167° F. the digestibility is not altered, but this degree of heat will destroy any saprophytic germs that the milk may contain. This process is best conducted in a steam sterilizer. Sufficient milk for one feeding is placed in separate bottles, loosely stoppered with absorbent cotton, which permits the escape of

steam, but prevents the admission of germs from the air. These bottles are placed in the sterilizer and allowed to steam for forty-five minutes. They are then placed upon ice until required for use. Pasteurizing will not destroy the toxalbumins or poisons the milk may have contained.

Milk contains oxidizing enzymes whose functions are to aid its digestibility. These enzymes are destroyed by heating above 167° F., and their presence is shown by shaking in a test-tube 10 c.c. of milk with 1 c.c. of freshly prepared tincture of guaiac, 5 c.c. of turpentine, and 5 c.c. of H_2O_2; a blue color will develop. The absence of such color indicates that the enzyme has been destroyed.

Detection of Preservatives in Milk.—Under no condition is it justifiable to use any chemical preservatives in milk, as they retard digestion.

Formaldehyd.—Into a test-tube place some H_2SO_4 containing a trace of ferric chlorid. Upon this add cautiously, so as not to mix the liquids, the milk to be tested, and in the presence of formaldehyd a blue or purple color will develop.

Borax or Boric Acid.—Place in an evaporating dish 1 drop of milk with 2 drops of HCl and 2 drops of tincture of turmeric. Dry the mixture on a water-bath, cool, and add 1 drop of NH_4OH by means of a glass rod. A greenish color indicates borax or boric acid.

Salicylic Acid.—Acidify 25 c.c. of the milk with

acetic acid, boil, and filter. The filtrate is extracted with ether by shaking in a separatory funnel. The ethereal extract is separated and shaken with a very dilute solution of ferric chlorid, which will impart a violet color to the aqueous layer if salicylic acid is present.

Benzoic Acid.—This is shown in a similar manner as the preceding test, but the filtrate is shaken with H_2O_2 before extracting with ether. The H_2O_2 converts the benzoic acid into salicylic acid.

Milk upon standing separates into two layers, the change being complete in twelve hours. The upper layer, known as the cream, contains practically all the fat. The lower layer is skimmed milk.

From the table of the composition of milk it will be seen that human milk differs from cows' milk in containing about half the percentage of proteins and inorganic salts and about one-third more of lactose, or milk-sugar. It also contains a protein rich in sulphur, *opalisin*, found exclusively in human milk. When the child is fed upon artificial milk it should be so modified as to contain the same percentage of the several ingredients as contained in mothers' milk. The quantities are not definite for the entire period of infant growth, and are changed periodically.

A graduate known as the "Materna" (Fig. 1) is made especially for this purpose, and simplifies the preparation of such milk without the need of any calculation. Its

outer circumference is divided into seven panels, each showing the quantity of milk-sugar, milk, cream, lime-

Fig. 1.—Estraus materna graduate.

water, and water to be used to produce a milk of desired strength for a child of certain age.

URINE

The urine is the most important animal excretion. In it are to be found the nitrogenous waste of catabolism and soluble mineral salts.

It varies widely in its composition, being influenced by the quantity and kind of food and drink, the state of digestion, muscular and nervous activity, temperature, etc.

AVERAGE COMPOSITION OF NORMAL URINE (after Holland)

	Percentage composition.	Grains per diem.	Grams per diem.
Water	96.000	50 fl.oz.	1200 c.c.
Solids, as tabulated below	4.000	1000 gr.	60.00 gm.
Urea	2.000	500 "	30.00 "
Uric acid	0.040	10 "	0.65 "
Hippuric acid	0.075	15 "	0.95 "
Creatinin	0.075	15 "	0.95 "
Pigment, mucus, xanthin, other extractives, etc.	0.680	170 "	10.00 "
Chlorids of sodium and potassium	0.680	170 "	10.00 "
Sulphates of sodium and potassium	0.110	40 "	2.60 "
Phosphates of magnesium and calcium	0.080	30 "	1.95 "
Phosphates of potassium	0.120	45 "	2.80 "

Besides these, there have been found traces of indican, phenol, and other aromatic sulphates, diastase, oxalic, and lactic acids, unoxidized sulphur, and phosphorus.

Color.—Normal urine is generally pale yellow or reddish yellow, but may be practically water white, due to taking excessive quantities of water. It may be dark brown when little water has been consumed. A brownish-green color indicates the presence of bile-pigments. The coloring-matter of urine is believed to be due to several agents, viz., *urobilin*, urochrome, hematoporphyrin, and uro-erythrin. Indican, a decomposition product, frequently adds color to the urine. Urine may be abnormally colored by certain vegetables, drugs, and chemicals, and also by blood and bile. Methylene-blue imparts a blue color; rhubarb, senna, and santonin impart a yellow color.

When first voided it is clear and transparent, with faintly aromatic odor and acid reaction. Upon standing, a cloudy film of mucus may be formed, which slowly sinks. Its acidity increases. If allowed to stand in a warm place it develops an ammoniacal odor, due to the action of the *bacteria urea* and *micrococcus urea* upon urea, converting them into ammonium carbonate.

Specific Gravity.—The specific gravity ranges from 1.012 to 1.030 or higher. A specific gravity over 1.030 indicates sugar. A urine of low specific gravity frequently denotes albumin. The specific gravity must be taken from the total urine passed in twenty-four hours.

Volume.—This varies under normal physiologic conditions. It may range from 900 to 1500 c.c.; decreased in acute nephritis; increased in chronic nephritis, diabetes mellitus, and diabetes insipidus.

Reaction.—It is generally acid, but may become neutral or alkaline shortly after passing. The acid reaction is due to monosodium phosphate, NaH_2PO_4.

Occasionally it may be both acid and alkaline (amphoteric), owing to its containing both alkaline and acid sodium phosphates.

Total Solids.—The average amount of total solids is about 60 grams per diem, of which one-half is urea. It can be approximately determined from the specific gravity by multiplying the last two figures of the specific

gravity by 2.2. For instance, 1450 c.c. of urine were voided in twenty-four hours with a specific gravity of 1.018. Multiplying the last two numbers of the specific gravity (18) by 2.2 yields 39.6 in 1000 c.c., or 57.42, for the 1450 c.c. For exact determination of total solids a definite volume of urine is evaporated on a water-bath, and the weight obtained is calculated for the total quantity passed in twenty-four hours.

Urea (N_2H_4CO) is the chief solid constituent of urine, and is also most important physiologically as well as pathologically. Urea is the chief nitrogenous end-product of the metabolism of proteins in the body, and carries off by far the largest quantity of all the nitrogen ingested with the food. The daily amount excreted is about 40 grams, equal to all the other solids of the urine. The determination of the amount of urea excreted gives us a clinical picture of the metabolic changes occurring within the body. In diabetes the amount of urea secreted is increased. In degenerative changes of the liver there is a diminution of urea formation.

Diet also plays an important rôle in the quantities of urea secreted. A protein diet will increase the urea output. Upon a strictly vegetable diet it is decreased.

Determination of Urea.—There are quite a number of methods suggested for the determination of urea. The simplest method giving fairly approximate results is Hinds' modification of Doremus'. The Doremus-Hinds' ureometer (Fig. 2) is filled with a solution con-

sisting of equal volumes of freshly prepared solution of chlorinated soda, "Labarraque's solution," and sodium hydroxid, care being taken to see that no air is present. The urine is placed in the graduated side tube and a

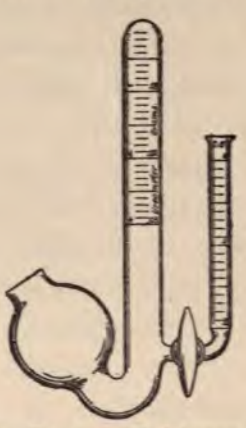


Fig. 2.—Doremus-Hinds' ureometer.

definite amount is allowed to pass into the ureometer. It is allowed to stand for thirty minutes and the percentage of urea is read off of the graduated scale of the ureometer.

PATHOLOGIC CONSTITUENTS OF URINE AND TESTS

Albumin.—Place some urine in a test-tube and heat upper portion. If a cloud appears, it may be due to albumin or phosphates. The lower cold portion will serve as a guide for comparison. Add a few drops of acetic acid until acid in reaction. If the cloud clears up, it is due to phosphates.

Heller's Test.—In a test-tube or, more preferably, a conical wineglass about 20 c.c. of urine is placed. To this is added, by means of a pipet, HNO_3 in such manner that the acid flows from the pipet to the bottom of the vessel, forming two distinct layers. If albumin is present, a white cloud will appear at the zone of contact.

Potassium Ferrocyanid.—10 c.c. of urine are acidified with 5 to 10 drops of acetic acid, and to the mixture is added a few drops of solution of potassium ferrocyanid. A turbidity will be produced in the presence of albumin. This test is extremely delicate, and gives no reaction with phosphates, peptones, mucus, alkaloids, urates, or pine acids.

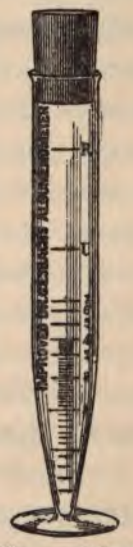


Fig. 3.—Esbach's albuminometer, improved form.

The quantitative determination of albumin may be readily carried out by Esbach's albuminometer. It will not give correct readings in amounts less than 0.5 part per 1000. When the albumin ranges high, that is, above "four" on the scale, it is advisable to dilute the urine with 1 or 2 volumes of water, and, after testing, to multiply the result by 2 or 3, according to the degree of dilution. If the urine was diluted with an equal volume of water, the result is multiplied by 2; if 2 volumes of

water were taken to 1 volume of urine, the result is multiplied by 3. The albuminometer consists of a strong glass tube, graduated as is shown in Fig. 3. The test solution consists of 10 grams of picric acid, 20 grams of citric acid, dissolved in sufficient water to make 1000 c.c., or 1 liter. The tube is filled to the mark "U" with clear urine, then up to the mark "R" with the reagent or test solution. The tube is closed with the stopper and the contents mixed by reversing the tube about ten times. It is then to remain in the upright position for twenty-four hours. The height of the sediment, read off on the etched scale, indicates the weight of dried albumin in 1000 parts of urine.

Carbohydrates.—Dextrose, or glucose, is present in minute amount in normal urine. It may also be present when large amounts of sugar are consumed and the system unable to burn it up, and is known as "alimentary glycosuria"; this is not a serious condition.

Determination.—Fehling's test solution of alkaline cupric tartrate:

Copper Solution No. 1.		Alkaline solution No. 2.	
Copper sulphate, in pure crystals	34.64 gm.	Potassium and sodium tartrate	173 gm.
Water sufficient to make	500.00 c.c.	Potassium hydroxid	125 "
		Water sufficient to make	500 c.c.

These solutions are preserved separately in small, well-stoppered bottles, and when required for use are mixed in equal proportions. If these solutions are

mixed and allowed to stand, the resultant solution decomposes and becomes worthless. To make sure that the solution is good it is tested by boiling, and if no change occurs it can be deemed to be all right.

The test is conducted by diluting the mixed Fehling's solution with some water and heating, keeping the solution just below the boiling-point. The urine is added drop by drop and a yellowish or brick-red precipitate will take place in the presence of sugar. If the quantity is small, this will only take place after standing for some time.

Haines' Test.—The reagent is made by dissolving 30 gr. of pure crystallized copper sulphate in ½ fluidounce of distilled water, adding ½ fluidounce of glycerin and 5 fluidounces of U. S. P. *Liquor potassa.* This solution is stable. In applying the test 1 dram of the solution is boiled in a test-tube, adding 8 to 10 drops of urine, and again boiling. In the presence of sugar a red precipitate of cuprous oxid, Cu_2O, is deposited.

Purdy's Test.—This is both a qualitative and quantitative method, and has the advantage of being quickly conducted, with a fair degree of accuracy.

The solution consists of the following:

Copper sulphate	4.742 gm.
Potassium hydroxid	23.500 "
Concentrated ammonia-water	450.000 c.c.
Glycerin	38.000 "
Water sufficient to make	1000.000 "

35 c.c. of this solution represents 0.020 gm. of glucose.

The test is conducted as follows: 35 c.c. of the solution are accurately measured from a buret and diluted with 2 volumes of water. From another buret the urine is slowly discharged, drop by drop, into the boiling solution contained in an evaporating dish until the color begins to fade, then more slowly, three to five seconds between each drop, until the blue color entirely disappears and a perfectly transparent colorless solution is produced. This must be done quickly, as it turns blue upon standing. The result is then calculated.

It requires 4 c.c. of urine to decolorize Purdy's solution. We know that the 35 c.c. represents 0.020 gm. of glucose; then by calculation we obtain:

Urine.	Glucose.	Urine.	Glucose.
4 c.c.	: 0.020	: : 100 c.c.	: x = 0.500 gm. in 100 c.c., or 0.5 per cent.

Böttger's Test.—In applying this test, the absence of albumin must be assured, as the bismuth will be turned black by the sulphur of the albumin. If albumin is present, it must first be removed by boiling and filtering.

To the urine an equal volume of KOH solution is added and a few grains of bismuth subnitrate, and boiled for half a minute. If sugar is present, a gray or dark brown deposit, finally becoming black, will be formed. The precipitate is either bismuth oxid or metallic bismuth, or a mixture of both.

Nylander's Test.—The solution is made by dissolving bismuth subnitrate, 2 gm., potassium and sodium tar-

trate, 4 gm., sodium hydroxid, 10 gm., in 90 c.c. of water and filtering; ½ c.c. of the solution is heated with 5 c.c. of urine. A brown or black precipitate will form after a few minutes' boiling, in the presence of sugar.

Blood.—Urine is made alkaline with NaOH and boiled. In the presence of blood, the precipitate of phosphates will be colored red. This test is not absolute, as any other coloring-matter the urine may contain will produce similar results. The precipitate is filtered and washed, and acetic acid added to the precipitate on the filter. In the presence of blood, the filtrate will be colored red, gradually disappearing upon exposure to air.

A mixture of freshly prepared tincture of guaiac and ozonized oil of turpentine is allowed to flow down the sides of a test-tube containing urine so as not to mix them. If blood is present a white ring, gradually turning blue, will appear at the point of contact of the two fluids. In place of the turpentine a mixture of H_2O_2 and ether may be used.

Benzidin Test.—10 c.c. of urine are treated with 1 c.c. of glacial acetic acid, and to the mixture a third of its volume of ether is added, with 5 to 10 drops of alcohol, and well shaken. Upon standing, the ether separates as an upper layer. By means of a pipet the ethereal layer is removed and transferred to another tube containing the benzidin reagent, made by mixing 0.5 c.c. of a freshly prepared solution of a little benzidin in 2 c.c.

glacial acetic acid with 3 c.c. H_2O_2. If blood is present, the reagent turns green or blue in two minutes; after five minutes it changes to a dirty purple.

Bile.—*Gmelin's Test.*—To a mixture of HNO_3, containing some nitrous acid, contained in a test-tube, some urine is added, so as not to mix the two liquids. If bile is present, a play of colors will be produced—green, blue, violet, red and yellow, or yellowish green.

Pettenkofer's Test.—Cane-sugar is dissolved in some of the urine to be tested, and concentrated H_2SO_4 is allowed to trickle down the side of the inclined test-tube. In the presence of bile, a play of color is seen, finally becoming cherry red.

Pus.—In the presence of pus, urine treated with solution of KOH will produce a tough, gelatinous mass.

H_2O_2 added to urine containing pus will give an effervescence of oxygen, but this is not absolute, as other substances the urine may contain will produce a similar result.

Indican.—Add to the urine an equal volume of HCl. Mix thoroughly, and then add a few drops of H_2O_2, and allow to stand a few minutes. To the mixture 5 c.c. of chloroform is added, and well shaken. Allow to stand, and if indican is present, the chloroform will be turned blue.

Acetone.—To a test-tube half-full of urine add a few drops of strong solution of NaOH and a 5 per cent. solution of sodium nitroprussid. The mixture be-

comes red, but will turn to purple by addition of an excess of glacial acetic acid, in the presence of acetone.

The urine is made alkaline with NaOH, boil, and filter. To the filtrate a few drops of Lugol's solution is added, and gently heated. If acetone is present small yellow crystals of iodoform will be produced.

Di-acetic Acid.—To the urine some solution of ferric chlorid is added, drop by drop, and the precipitate of iron phosphate is removed by filtration. The filtrate is treated with more ferric chlorid, when, in the presence of diacetic acid, a wine color is produced, disappearing upon boiling.

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Books for Nurses

PUBLISHED BY

W. B. SAUNDERS COMPANY

West Washington Square Philadelphia

London: 9, Henrietta Street, Covent Garden

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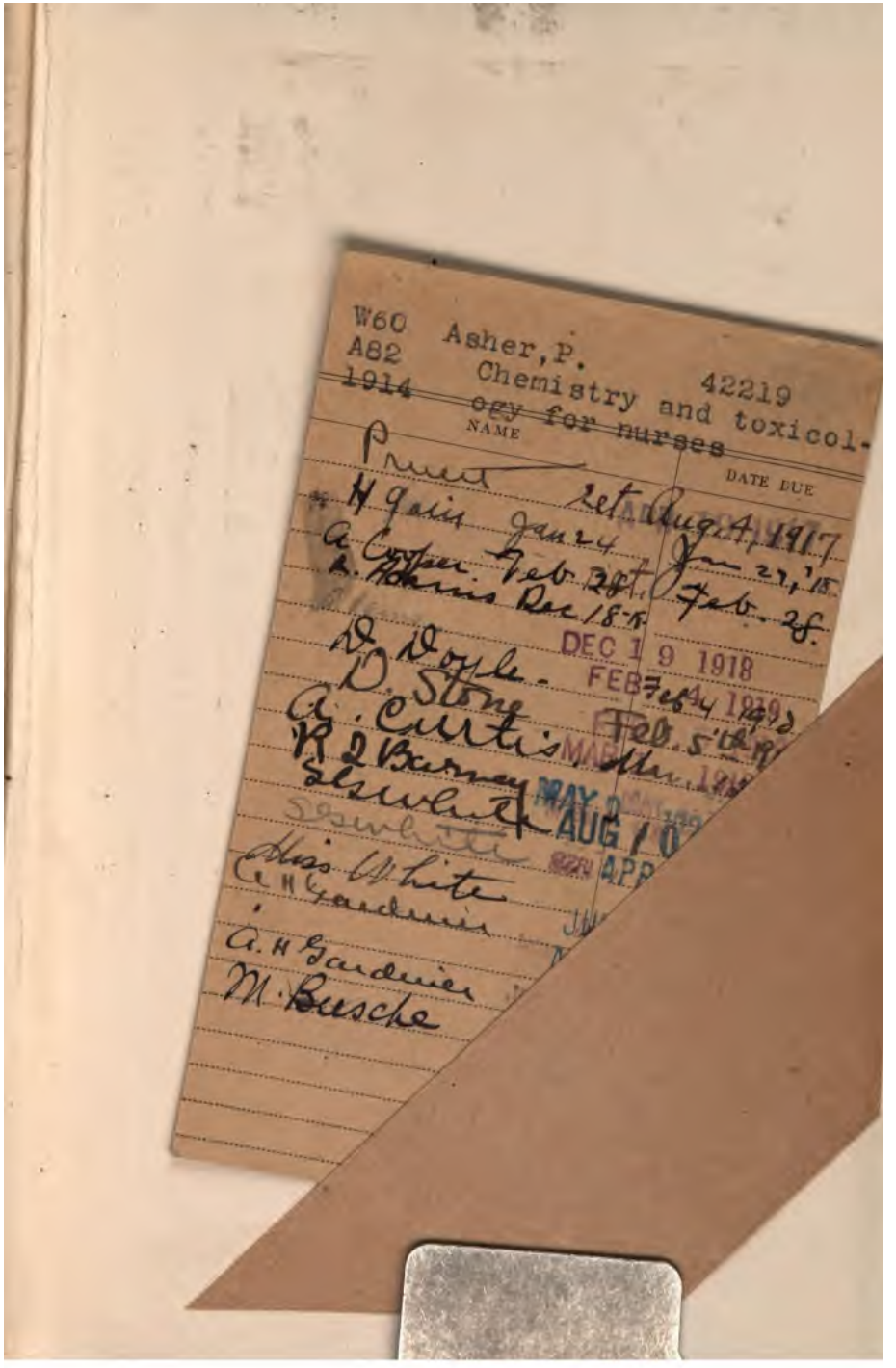
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